May 1959 75c.

pg 53 137

EMICONDUCTOR PRODUCTS

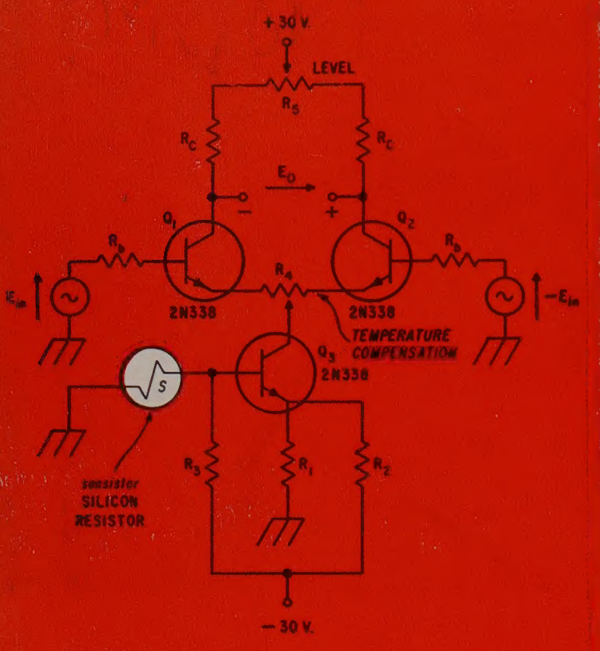
Measuring Transistor Switching Times

Transistors as Tuned Power Amplifiers at VHF

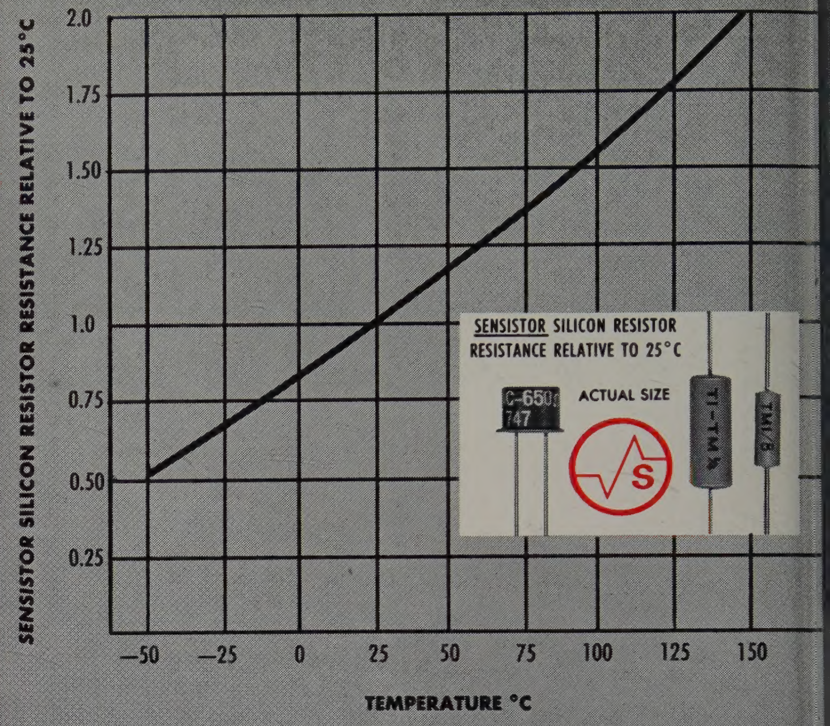
Avalanche Noise in P-N Junction

Micro Modules Using Transistors

TI APPLICATION NOTE



DIFFERENTIAL DC AMPLIFIER USING *SENSISTOR* SILICON RESISTOR.
Write on your company letterhead for additional applications and data sheet.



HOW TO INCREASE DIFFERENTIAL DC AMPLIFIER STABILITY WITH *sensistor** SILICON RESISTORS

Low drift transistor amplifier circuit using *sensistor* silicon resistor gives drift performance superior to vacuum tube amplifiers for low source impedance applications.

The sensistor silicon resistor has a unique positive temperature coefficient of +0.7%/°C plus a constant rate of change as shown in the graph to the right. Over a 15°C temperature range, the *sensistor* silicon resistor's temperature-resistance curve approaches linearity to an extent that allows its use as a compensating component in a differential D-C amplifier.

This low drift amplifier finds a wide range of low source impedance applications in airborne telemetry where the performance of other types of D-C amplifiers is limited by weight requirements, acceleration, shock, and vibration. It is particularly useful with low level transducers such as thermocouples, strain gages and accelerometers.

DESIGN CONSIDERATIONS

TI 2N338 silicon transistor provides excellent performance as a low drift DC amplifier when used in circuits such as the one shown above.

For optimum performance keep $(2R_b + R_4)$ as small as possible, preferably less than 2000Ω, and the collector currents of Q_1 and Q_2 should remain below 100 μA.

*TRADEMARK OF TEXAS INSTRUMENTS

Drift cancellation featured in an uncompensated differential configuration provides an amplifier with an equivalent input drift of 400 μV/°C or less with standard production transistors.

Drifts as low as 6μV/°C will result if the compensating circuit composed of Q_3, sensistor resistor S and their biasing resistors is used with a matched pair of transistors.

CIRCUIT OPERATION

Sensistor resistor S and its biasing resistor R_3 serve as a voltage source which has an output linearly related to temperature . . . level potentiometer R_5 adjusts output voltage E_o to zero when E_{in} is zero . . . potentiometer R_4 adjusts for minimum output drift due to ambient temperature changes.

As temperature increases, the resistance value of S also increases causing the base of Q_3 to go more negative, thereby reducing the collector current of Q_3. This temperature-dependent current is fed into the differential amplifier through R_4.

Depending on the wiper position of R_4, the correcting signal may be positive, negative or zero. When the wiper is centered, zero correction results. As temperature increases, output voltage E_o tends to go more positive if the R_4 wiper is placed nearer the Q_2 emitter and negative if the wiper is placed nearer Q_1. The optimum setting for R_4 can be determined by cycling over the desired temperature range to give a minimum drift for changes in ambient temperature.

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from THE WORLD'S LARGEST SEMICONDUCTOR PLANT

TEXAS INSTRUMENTS
INCORPORATED
SEMICONDUCTOR-COMPONENTS DIVISION
POST OFFICE BOX 312 · 13500 N. CENTRAL EXPRESSWAY
DALLAS, TEXAS

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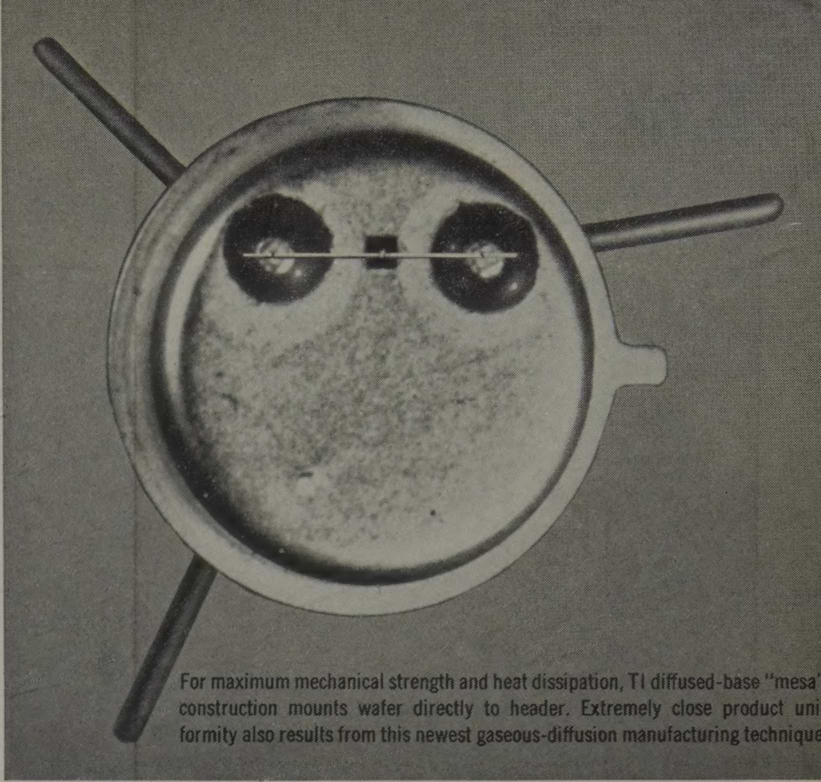

For maximum mechanical strength and heat dissipation, TI diffused-base "mesa" construction mounts wafer directly to header. Extremely close product uniformity also results from this newest gaseous-diffusion manufacturing technique

750 MC • 750 mW
ALPHA CUTOFF — MAX DISSIPATION

TUAL SIZE

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l units are 100% production stabilized at temperares well above their 100°C rated junction operating int . . . exceed MIL-T-19500A specifications . . . and e *in stock now.*

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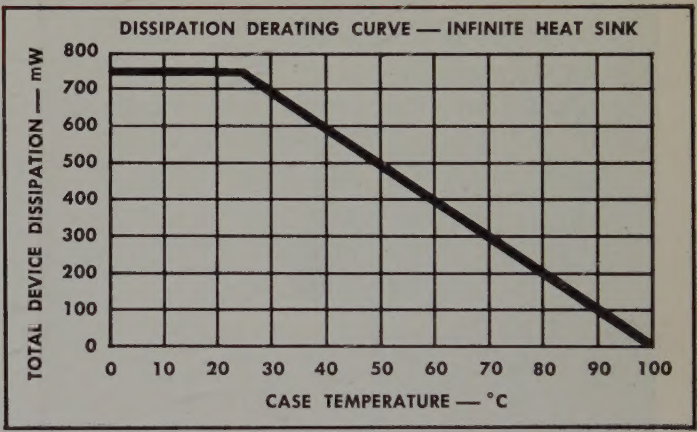

absolute maximum ratings @ 25°C case temperature

	2N1141	2N1142	2N1143	
Collector Voltage Referred to Base	−35	−30	−25	V
Emitter Voltage Referred to Base	−1	−0.7	−0.5	V
Collector Current	−100	−100	−100	mA
Emitter Current	100	100	100	mA
Device Dissipation (infinite heat sink)	750	750	750	mW
Collector Junction Temperature	+100	+100	+100	°C
Storage Temperature Range		−65 to +100		°C

typical characteristics @ 25°C case temperature

Frequency Cutoff (Common Base)	750	600	480	MC
Collector Reverse Current, $V_{CB} = -15V$, $I_E = 0$	1	1	1	μA
Saturation Voltage, $I_C = -70mA$, $I_B = 17.5mA$	2	2	2	V
Thermal Resistance Junction to Mounting Base	0.1	0.1	0.1	°C/mW
Small Signal Short Circuit Forward Current Transfer Ratio,	$10 I_C$	$50 I_C$	$100 I_C$	mA
$V_{CB} = -10V$, f = 1000cps	0.97	0.85	0.75	

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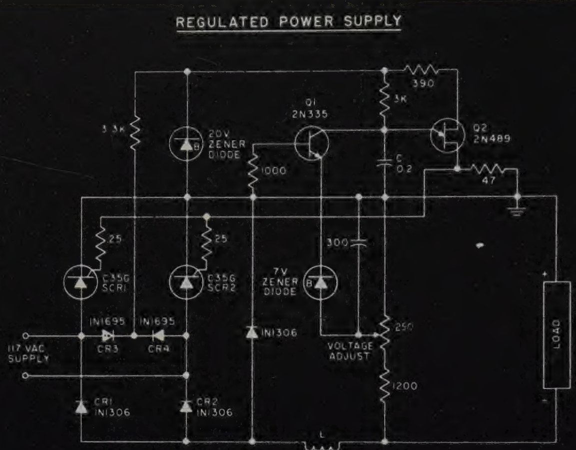
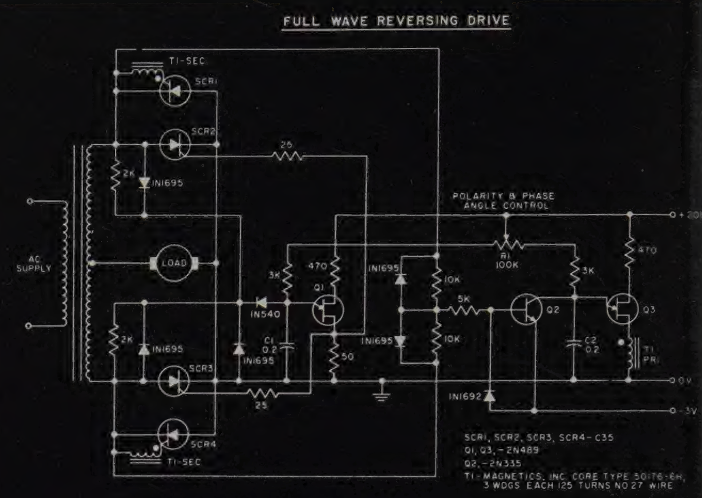
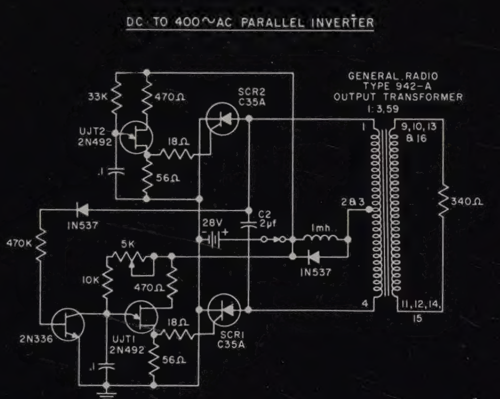
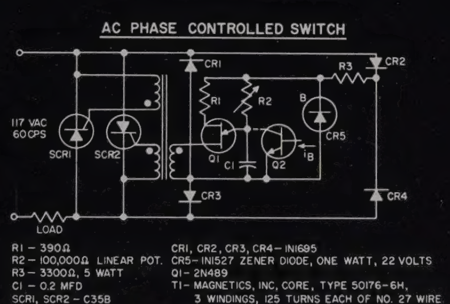
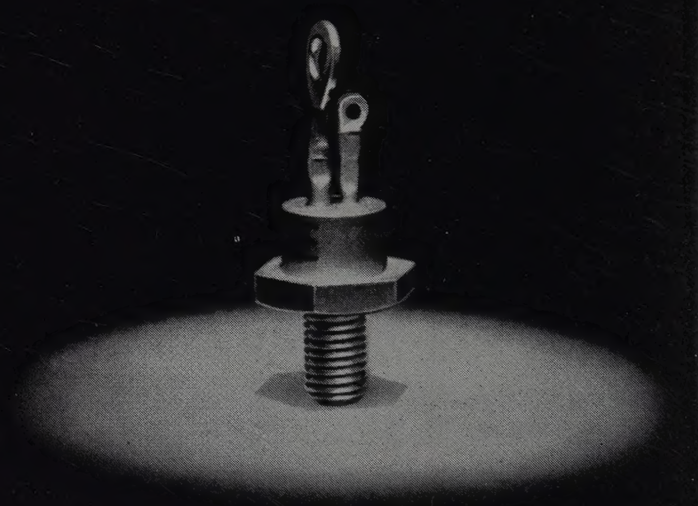
New prices, new circuits for











FOUR BASIC CIRCUITS. Above are four basic designs for the Controlled Rectifier using the unijunction transistor as the firing means. The unijunction is a precision trigger, putting out short, high current pulses. The frequency of these pulses will not vary with the supply voltage or temperature, yet can be variably controlled with a silicon triode from a low level feedback signal. Unijunction firing circuits are easily synchronized with 60 cycle line frequency. In short, the unijunction provides the simplest and least expensive means for precision firing of the Silicon Controlled Rectifier.

General Electric's new silicon medium-current rectifiers, Types 1N2154 thru 1N2160, are ideal as companion devices to the controlled rectifier for reverse-voltage protection and, also, for applications in full-wave circuitry.

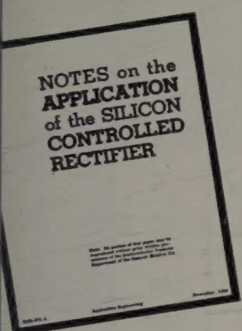
SAMPLE LIST OF POWER HANDLING AND OTHER JOBS THAT CAN NOW BE DONE BETTER BY THE G-E CONTROLLED RECTIFIER

- Converters, DC to DC, DC to AC
- Phase controlled DC power supplies, regulated & unregulated
- Frequency converter, current control
- Power switch for automatic temperature control electronic flash
- Reversible motor control
- AC variable speed induction motor
- Dynamic braking
- Light dimmers
- Thyratron replacement for relay drivers
- Pulse width conversion
- High speed printer for digital computer
- Welding control
- Ignitron firing
- Circuit breaker replaceme

revolutionary G-E Controlled Rectifier

"Controlled rectifiers may revolutionize the electrical industry." This statement was made a year ago by a respected news publication. Since then samples have been studied by hundreds of firms. Many new circuits have been developed which promise important improvements in functions, reliability, simplicity, accuracy and lower cost. In just one year prices have been reduced 75 percent (see chart below). And now, the G-E Silicon Controlled Rectifier is a standard, production-line item, warranted in writing and available at sharply reduced prices.

This is the time for design engineers to exploit the inherent advantages of the Silicon Controlled Rectifier in their circuit designs. Many applications are proved . . . the firing circuits have been refined . . . the product line is stabilized . . . and it makes sound economic sense. Call or write your G-E Semiconductor Sales Representative for complete details. The Controlled Rectifier is also available from many local G-E Distributors.



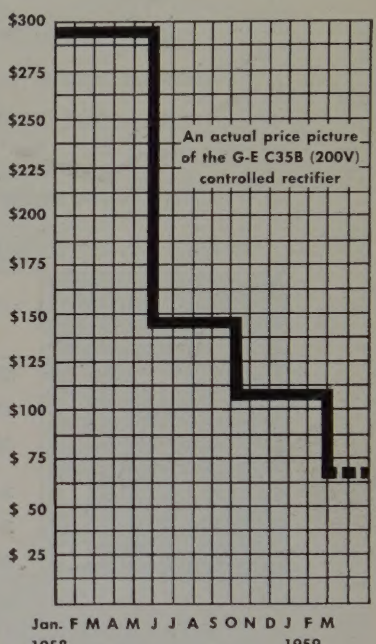
HOW THE G-E CONTROLLED RECTIFIER WORKS. The Silicon Controlled Rectifier is a three junction semiconductor device for use in power control and power switching applications requiring blocking voltages up to 400 volts and load currents up to 16 amperes. Series or parallel circuits may be used for higher power applications.

The G-E Controlled Rectifier's reverse characteristic is similar to a normal silicon rectifier in that it represents essentially an open circuit with negative anode to cathode voltage. The forward characteristic is such that it will block positive anode to cathode voltage below a critical breakover voltage if no signal is applied to the gate terminal. However, by exceeding the forward break-over voltage or applying an appropriate gate signal the device will rapidly switch to a conducting state and present the characteristically low forward voltage drop of a single junction silicon rectifier.

DETAILED NOTES are available on the application of the G-E Silicon Controlled Rectifier, plus reprints of articles that have appeared in technical journals. Write to Section S84559, Semiconductor Products Dept., General Electric Company, Electronics Park, Syracuse, New York.

STEADY PRICE DROP. Since its introduction one year ago, the price of the typical G-E Controlled Rectifier has dropped more than 75 percent. This results from improved manufacturing techniques and volume production. The G-E Controlled Rectifier is now a production-line item, warranted in writing for one year and subjected to the same quality control tests imposed on all General Electric transistors and rectifiers.

The G-E Controlled Rectifier is also available at even less cost (ZJ39L series) for use at 100°C and below, with currents up to 10 amperes.



MAXIMUM ALLOWABLE RATINGS (Resistive or Inductive Load)

	C35U	C35F	C35A	C35G	C35B	C35H	C35C	C35D
Continuous Peak Inverse Voltage (PIV)	25	50	100	150	200	250	300	400 volts
Transient Peak Inverse Voltage (Non-Recurrent <5 millisec.)	35	75	150	225	300	350	400	500 volts
RMS Voltage (V_{RMS}), Sinusoidal	17.5	35	70	105	140	175	210	280 volts
Average Forward Current (I_F)	Up to 16 amperes							
Peak One Cycle Surge Current (I_{surge})	150 amperes							
Peak Gate Power	5 watts							
Average Gate Power	0.5 watts							
Peak Gate Current (I_G)	2 amperes							
Peak Gate Voltage (V_G) (forward)	10 volts							
Storage Temperature	−65°C to +150°C							
Operating Temperature	−65°C to +125°C							

CHARACTERISTICS (At Maximum Ratings)	C35U	C35F	C35A	C35G	C35B	C35H	C35C	C35D
Minimum Forward Breakover Voltage (V_{BO})	25	50	100	150	200	250	300	400 volts
Maximum Reverse (I_R) or Forward (I_S) Leakage Current (Full Cycle Average)	6.5	6.5	6.5	6.5	6.0	5.5	5.0	4.0 ma
Maximum Forward Voltage ($V_{F\,AVG}$)	0.86 volts (Full Cycle Average)							
Maximum Gate Current To Fire (I_{GF})	25 ma							
Maximum Gate Voltage To Fire (V_{GF})	3 volts							
Typical Gate Current To Fire (I_{GF})	10 ma at +1.5 volts (Gate to Cathode Voltage)							

ZJ39L Series—lower cost series with ratings similar to above, but for use up to 100°C maximum, with forward current ratings up to 10 amperes.
ZJ50 Series—a high-current series now in development, and available on a prototype-sample basis.

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PNP

SILICON TRANSISTORS

NPN

in quantity production

Other significant advantages include:

- Low saturation voltage
- Twenty volts BVEBO
- Low noise type available in both PNP and NPN
- Minimum change in characteristics with temperature, current, and voltage
- Suitability for complementary circuits

For both PNP and NPN Silicon Transistors specify RAYTHEON

FOR LARGE SIGNAL APPLICATIONS (Temperature Range −65°C to +160°C)

Package		Type	I_{EO} or I_{CO} at $V_{CB} = 20\ V_{dc}$ µA	V_{CE} max. volts	H_{FE}† ave.	r_b' f = 1Mc ohms	r_c kilohms	Noise Figure db (max.)	C_{ob} f = 100Kc ave. µµf	$f_{\alpha b}$ ave. Kc
TO-5 (0.335" max., 0.260" max.)	P	2N327A	0.005	−40	15	1200	500	30	65	200
	N	2N328A	0.005	−35	30	1400	500	30	65	300
E3-44	P	2N329A	0.005	−30	60	1500	500	30	65	400
	N	2N619	0.005	50	15	2000	500	30	35	200
	P	2N620	0.005	40	30	2500	500	30	35	350
	N	2N621	0.005	30	60	2700	500	30	35	500

†for PNP, $I_B = -0.1mA$; $V_{CE} = -0.5V$; for NPN, $I_B = 0.5mA$; $V_{CE} = 1.5V$

FOR SMALL SIGNAL APPLICATIONS (Temperature Range −65°C to +160°C)

Package		Type	I_{EO} or I_{CO} at $V_{CB} = 20\ V_{dc}$ µA	V_{CE} max. volts	h_{fe}* ave.	h_{ie}* max. ohms	h_{oe}* max. µmhos	Noise* Figure db	C_{ob} f = 100Kc ave. µµf	$f_{\alpha b}$ ave. Kc
TO-5 (0.335" max., 0.260" max.)	P	2N1034	0.005	−40	15	3000	70	30	65	200
	N	2N1035	0.005	−35	30	3000	85	30	65	300
		2N1036	0.005	−30	60	3000	100	30	65	400
E3-44	P	2N1037	0.005	−35	30	3000	85	15	65	250
	N	2N1074	0.005	50	15	3500	70	30	35	200
	P	2N1075	0.005	40	30	3500	85	30	35	350
		2N1076	0.005	30	60	3500	100	30	35	500
	N	2N1077	0.005	30	25	3500	85	15	35	300

$^*V_C = 5V; I_E = 3mA$

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Front Cover

All the transistorized micro-module electronics of a military radio receiver equal to a six-transistor commercial type fit into a teaspoon with room to spare at Signal Corps and RCA demonstration of progress in the Army micro-module program. Cubical micro-modules, measuring a third of an inch on each side, are made of micro-elements stacked to form modules which perform complete circuit functions. Photo, courtesy RCA.

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NOTE: *Doped single crystals in other diameters, resistivities, or lifetimes not listed above can be furnished as specials.*

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For additional information on specific applications and processes, write Merck & Co., Inc., Electronic Chemicals Division, Department ***ES-4,*** *Rahway, New Jersey.*

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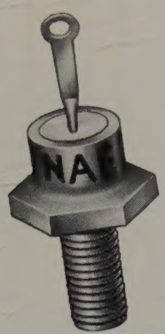

MEDIUM POWER SILICON RECTIFIERS

High current — 7/16 stud base

MAXIMUM CASE TEMPERATURE RATINGS

NAE Number	Peak Inverse Voltage	Maximum Average Rectified Current (amps) 50°C	150°C	Maximum Surge Current (5 milliseconds)	Forward Voltage at Specified Current at 25°C	Maximum Average Inverse Current (ma)
NA17	100	10	3	60 amps	1.lv at 3 amps	.5
NA27	200	10	3	60 amps	1.lv at 3 amps	.5
NA37	300	10	3	60 amps	1.lv at 3 amps	.5
NA47	400	10	3	60 amps	1.lv at 3 amps	.5
NA57	500	10	3	60 amps	1.lv at 3 amps	.5
NA67	600	10	3	60 amps	1.lv at 3 amps	.5

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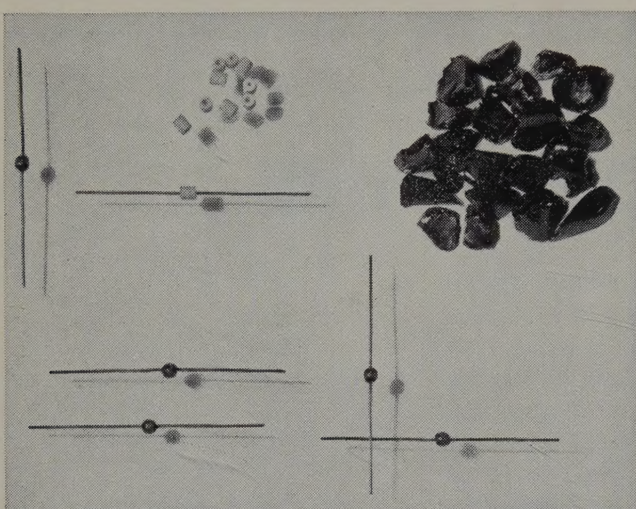

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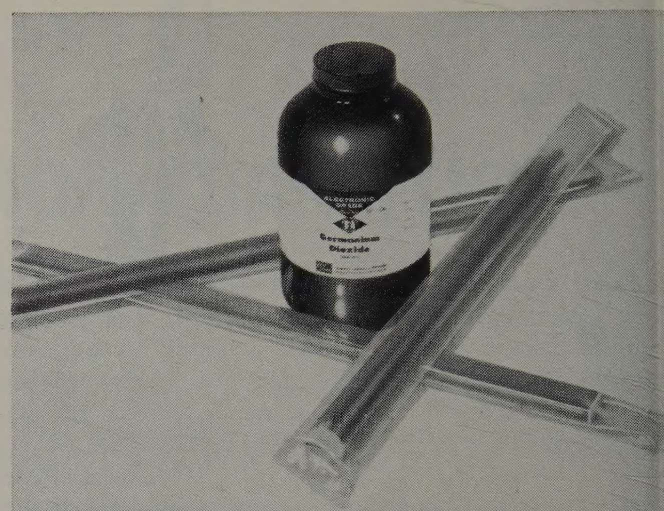

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1N458°	1N463	1N627	1N482B	1N485
1N459°	1N464	1N628	1N483	1N485A
		1N629	1N483A	1N485B
			1N483B	1N486
			1N484	1N486A

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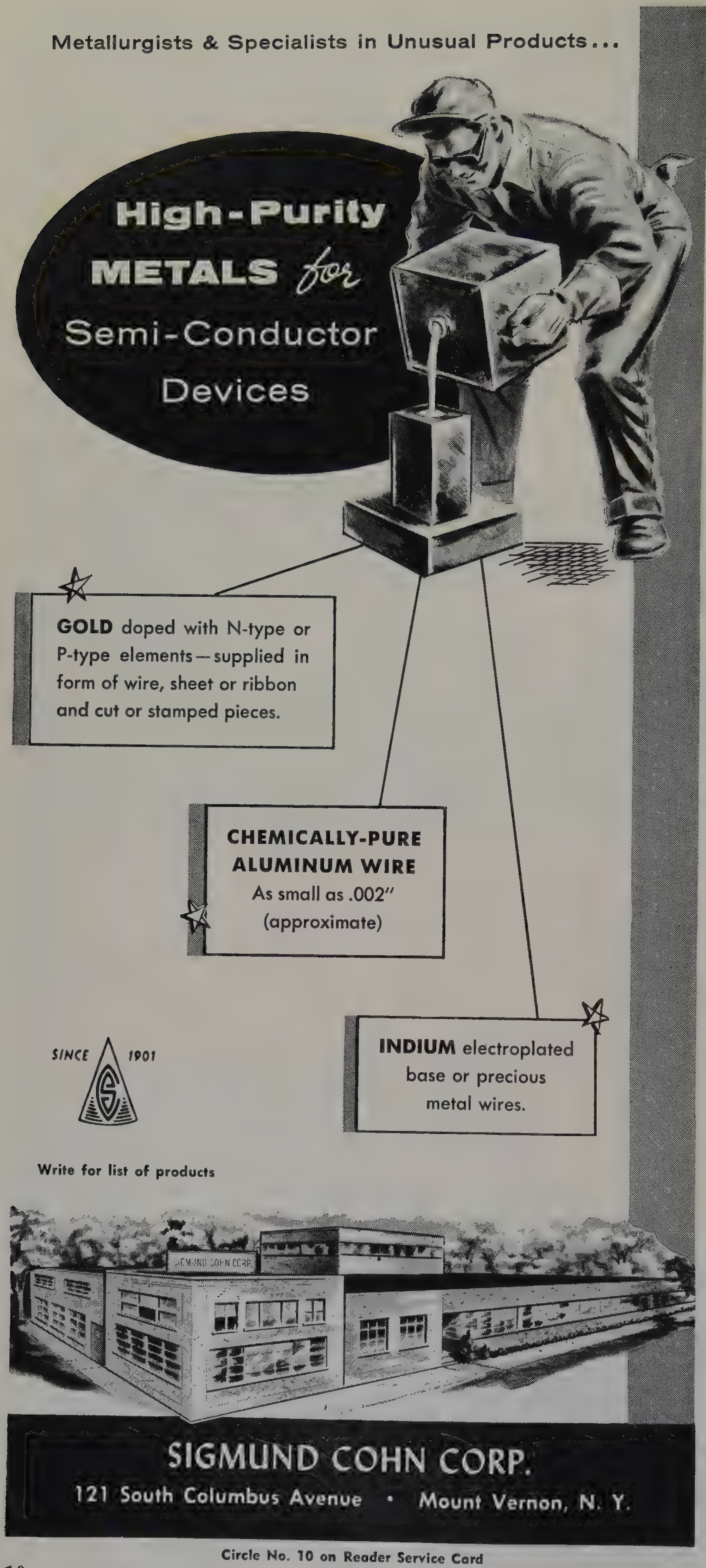

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BOOK REVIEWS . . .

TITLE: Transistor Technology Vol. I

AUTHORS: Bridges, Scaff, Shive

PUBLISHER: Van Nostrand, New York

Transistor Technology, Volume I, is one of the Bell Laboratories Series of the basic works on the processes of the manufacture of transistors.

Chapter I of the first section is devoted to methods of recovery of pure germanium from germanium dioxide by a two-step reduction in hydrogen at elevated temperatures. The actual process is described in detail, from raw material to final ingot, together with methods of test.

Chapter II is devoted to a thorough description of the *zone-melting* processes. The normal-freezing method of purification is defined with a complete discussion of merits and disadvantages. Purification by zone-refining is considered in terms of a careful mathematical analysis. The process is described in considerable detail with precautions, methods of test, and descriptions of equipment used.

Part II of the book deals with the preparation of single crystals. The germanium lattice must be well defined, and known amounts of impurities must be added to the crystal which is separated from the germanium melt by means of a pulling process. The distribution of solute elements is treated in detail in chapter five with transient methods of impurity addition outlined in Chapter VI. Mechanical preparation of germanium single crystals, with resistivity controls and techniques of evaluation are clearly discussed in Chapter VII.

Part III of *Transistor Technology* is entitled: "Principles of Device Fabrication," and constitutes the major part of the book. The complete evolution of the transistor from design theory to final encapsulation is explained. The book omits practically no details, from diamond-saw dicing to final electrode attachment.

The balance of the book, Part IV, is devoted to principles of transistor performance, characterization. The electrical equivalent circuit of the transistor is developed as an introduction to measurement techniques. The book also contains a complete listing of various transistor parameter terms as found in the literature and is recommended by the I. R. E.

Transistor Technology, Volume I, is a profusely illustrated, well written, basic source of information about the manufacture of transistors. There is much to be learned from the lucid descriptions of the physical problems, as well as methods of evaluation. This book is current, and perhaps the most complete single source of information about laboratory processes in the development and production of the transistor.

TITLE: Transistor Technology Vol. II

AUTHOR: Edited by F. J. Biondi

PUBLISHER: Van Nostrand

Volume II of the Bell Telephone Laboratories Series *TRANSISTOR TECHNOLOGY* is a continuation of the presentation of methods of development of the transistor. This volume stresses

the design of the transistor in terms of desired characteristics.

The book is divided into two sections: Technology of Materials and Principles of Transistor Design. The first section opens with a chapter discussing recent advances in silicon. Because of its higher melting point silicon offers obvious advantages over germanium however, the purification process is more difficult. Methods and equipment used to obtain high purity polycrystalline silicon are outlined. Chapter II discusses the semiconductor properties as affected by impurities and techniques for control of the refining. Chapter III describes the zone-leveling process and crystalline perfection.

The second section of the book, Principles of Transistor Design, develops the actual engineering design of the transistor starting with the *p-n* diode. A rigorous mathematical treatment of the characteristics of this device together with a fairly complete treatment of the diode design principles follow in Chapter IV.

The design of the junction triode transistor follows in the fifth chapter, a veritable 200 page book in itself. Here the transistor is considered first as an electronic switch then as a transmission device. The structure and operation of the transistor is described. There are sections on power gain and high frequencies, optimum design of power ouput transistors and performance in terms of the physical structure.

Chapter VI deals with switching device design; Chapter VII with tetrodes. The behaviour of Noise Figure in junction transistors is treated in an unusually clear manner in Chapter X. Conditions for minimum Noise Figure are deliniated and the effects of variation of operating point on the Noise Figure are stated. A complete calculation for noise in the common base configuration may be found in the Appendix I of this chapter. The final chapter of the book (XI) treats the design implications of surface phenomena or controlled surface effects in semiconductors.

Transistor Technology Volume II is a complete collection of many previously published papers and articles together with a considerable amount of unpublished material-concerning principles of design. The book is complete, thorough and well edited and provides a practical reference to the technologies of materials and design.

TITLE: Transistor Physics and Circuits

AUTHORS: Robert Riddle and Marlin Ristenbatt

PUBLISHER: Prentice-Hall, Inc.

The authors of *Transistor Physics and Circuits* state at the outset that the book is written for those technicians and designers who wish to obtain an *understanding* of transistors. The book aptly succeeds in this undertaking.

Chapters I and II of Section 1, which is titled *Physics* are an elementary review of physics with much of the work geared to lead the reader to the physical concepts presented in Chapter III which is titled "Semiconductors." The crystalline properties of the silicon and germanium crystal are clearly defined and the action of free electrons in non-intrinsic semiconductors is considered.

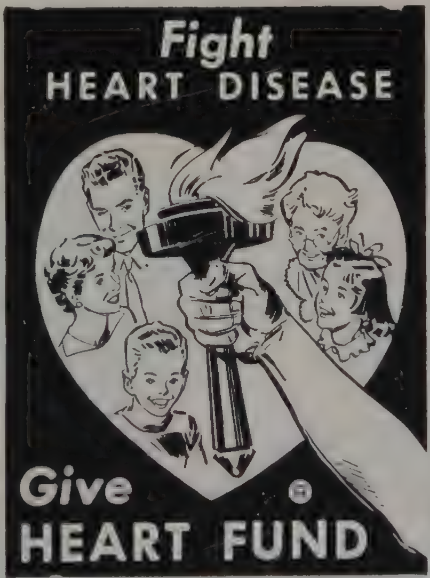
Chapters IV and V establish the transistor as a logical outgrowth of the *p-n* junction diode. The physical action of the transistor is clearly analyzed. The *p-n-p* and *n-p-n* transistors are introduced together with concepts of cutoff current (I_{co}) and current gain (h_{fe}). The actual construction and various types of transistors are summarized in Chapter V together with the specific type characterizations.

The second part of the book is entitled "Circuits" and contains ten chapters on the many aspects of circuit design. Basic electrical engineering is introduced in terms of circuit quantities, passive circuit elements, current and voltage source concepts and methods of circuit analysis. This is followed by the transistor as a circuit element with techniques of analysis of the transistor characteristics. The transistor is presented as a small-signal-amplifier and the circuit concepts are carefully developed.

The balance of this book deals with a variety of topics. Power amplifiers, cascade amplifier, bias stability and *d-c* amplifiers are several of the many types of circuitry discussed. The chapters on Feedback (Chapter XII) and Noise (Chapter XIII) are especially interesting and concise. A chapter on transistor oscillators (Chapter XIV) and a chapter devoted to transistor experiments and circuitry complete the work. The appendices are of value to the advanced student in the presentations of determinants and parameter conversions.

Transistor Physics and Circuits is a simplified, non-mathematical treatment of the transistor in terms of circuitry and physical operation. The advanced technician, radio amateur and uninitiated engineer will find this book an excellent introduction.

Stephen E. Lipsky



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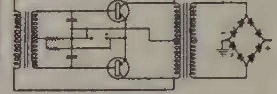

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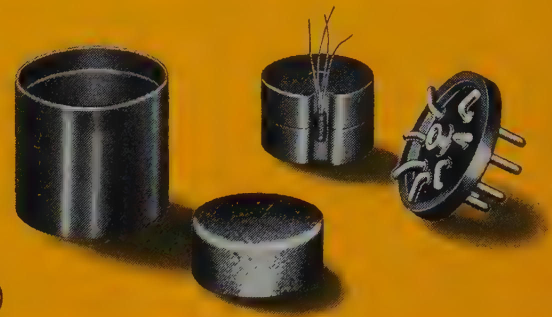

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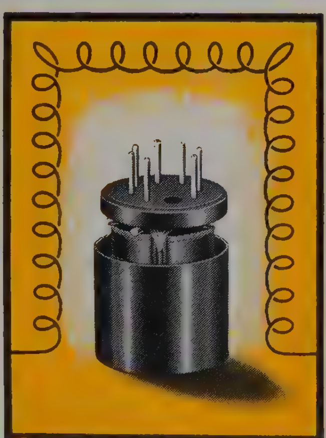

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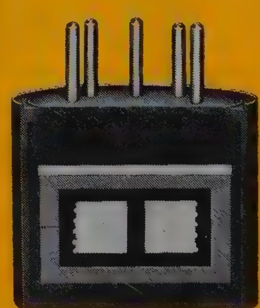

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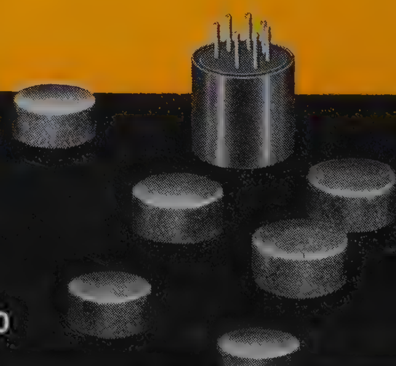

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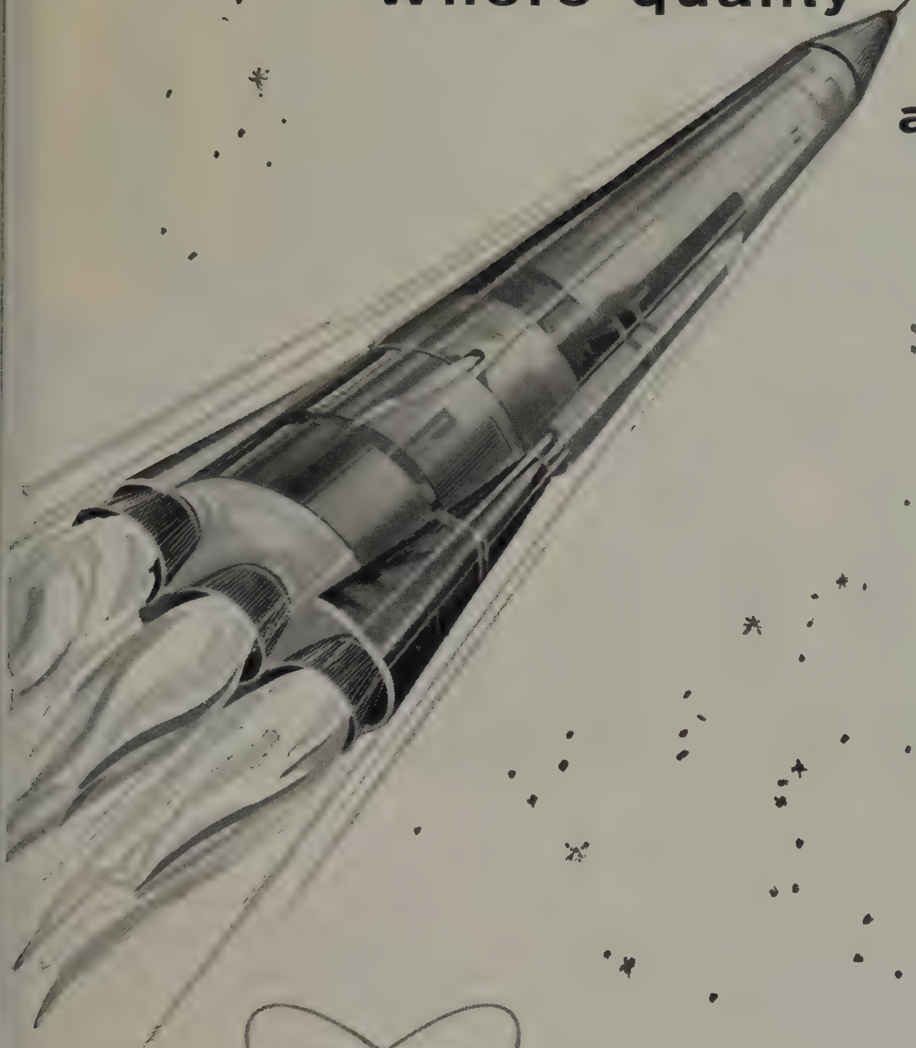

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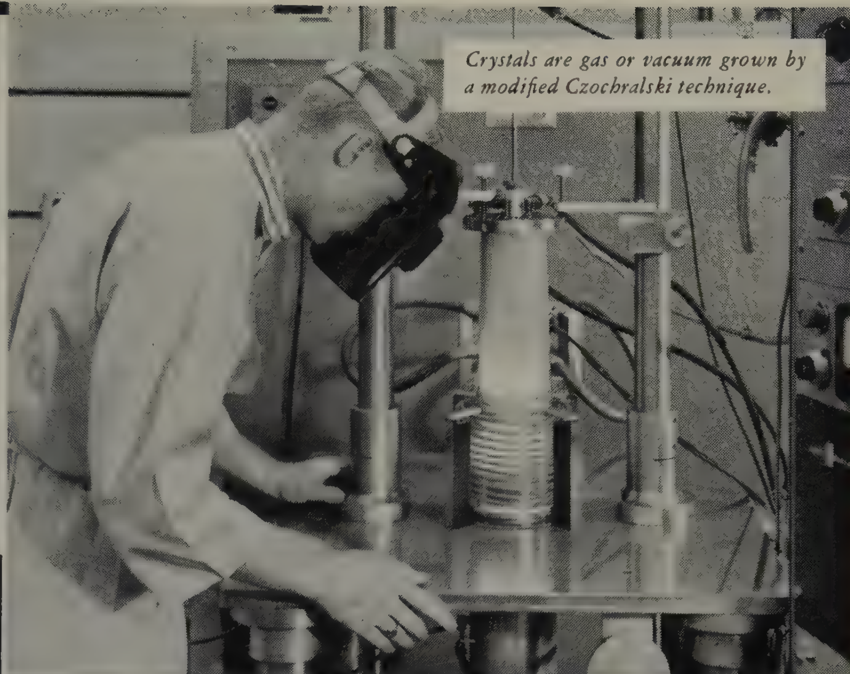

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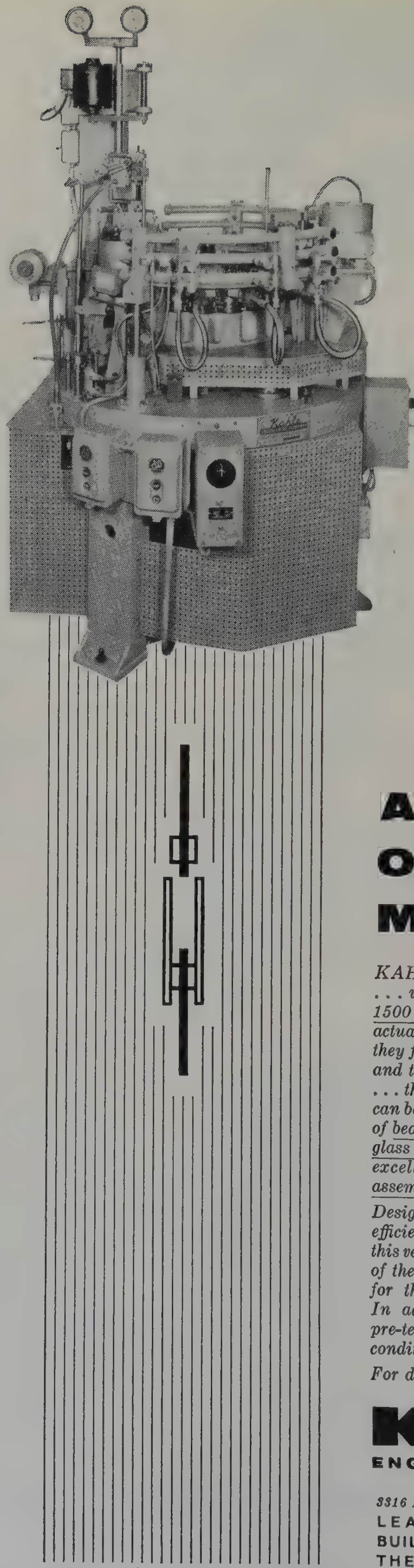

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Editorial . . .

J. J. Ebers

Dr. J. James Ebers, Assistant Director of Development of the Allentown and Laureldale (Penna.) Laboratories, Bell Telephone Laboratories died March 30 at Allentown General Hospital. Dr. Ebers, who was 37, had been ill six weeks. He resided at 721 North 3rd Street, Emmaus, Penna.

A native of Grand Rapids, Michigan, Dr. Ebers received his B.S. degree from Antioch College in 1946, and the degrees of M.S. in E.E. in 1947 and Ph.D. in 1950 from Ohio State University. While doing graduate work he was an instructor and later assistant professor in the electrical engineering department, and also was engaged in research and development of microwave electron tubes.

In September 1951 Dr. Ebers joined the technical staff of Bell Telephone Laboratories. He specialized in development of transistors for switching applications and made several contributions to the theory and analysis of transistors, particularly as applied to switching and computing circuits. He held several patents on transistors and electron tubes and was the author of numerous papers on these subjects.

He was a member of the American Physical Society and a Senior Member and Chairman of the Lehigh County chapter of the Institute of Radio Engineers. He was also a member of Eta Kappu Nu and Sigma Xi, honorary professional fraternities.

Surviving are the widow, Patricia Huntington Ebers, four children, Michael, Marcy, Douglas and Thomas, and Dr. Ebers' parents, Mr. and Mrs. Avery Ebers of Newaygo, Michigan.

The Hall Effect

It was found by Hall in 1879 that an external magnetic field can distort the equipotential lines of a current carrying conductor. If current is passed through a metal or semiconductor strip whose plane is perpendicular to the magnetic field, a voltage is produced in the direction perpendicular to the magnetic field and the current. Considering a rectangular strip of length L, width a and thickness b, the "Hall voltage" is $V_H = R\ B\ i/b$ where R is a coefficient (called "Hall constant") function of the densities and mobilities of electrons and holes in the specimen. For an intrinsic semiconductor, if B is in Wb/m^2, i in amperes and b in meters, one has $R = -3\pi/8\ q\ n_i$ (m^3/Coul); for a doped semiconductor with carrier mobilities μ_n and μ_p, R is given by the expression

$$R = -\frac{3\pi}{8q}\ \frac{\mu_n{}^2 n - \mu_p{}^2 p}{(\mu_n n + \mu_p p)^2}$$

The latter quantity is maximum when $n = n_i\ \sqrt{3\mu_p/\mu_n}$. Largest values of R are obtained with certain compound semiconductors, such as indium arsenide and indium antimonide.

The Hall plate acts as a two port, non-reciprocal transducer whose input power is limited by the heat produced by the current i flowing through the specimen, and whose available output power is proportional to $\mu^2{}_n$ for given input power, and is maximum for n-type materials.

Obvious applications of the Hall effect are: in the field of multipliers, if i and B are made proportional to the quantities to be multiplied; in the field of magnetic field measurements, if the current i is maintained constant; in the field of current measurements, if the magnetic field B is maintained constant.

It is of interest to note that the product indicating Hall voltage is independent of waveforms, frequency and phase of the component factors. Hence the multiplier can be placed inside a wave guide, where the local B and E fields provide a direct measurement of the power.

The Hall effect may be applied also to the construction of amplifiers (feeding input power into the magnetic field), of unilateral transducers, of modulators (feeding *r-f* carrier current i and modulating signal B), as *d-c* current clip-on meters (utilizing the magnetic field produced by the current) as pick-ups or microphones, or as displacement gauges (placing the specimen in a highly variable magnetic field).

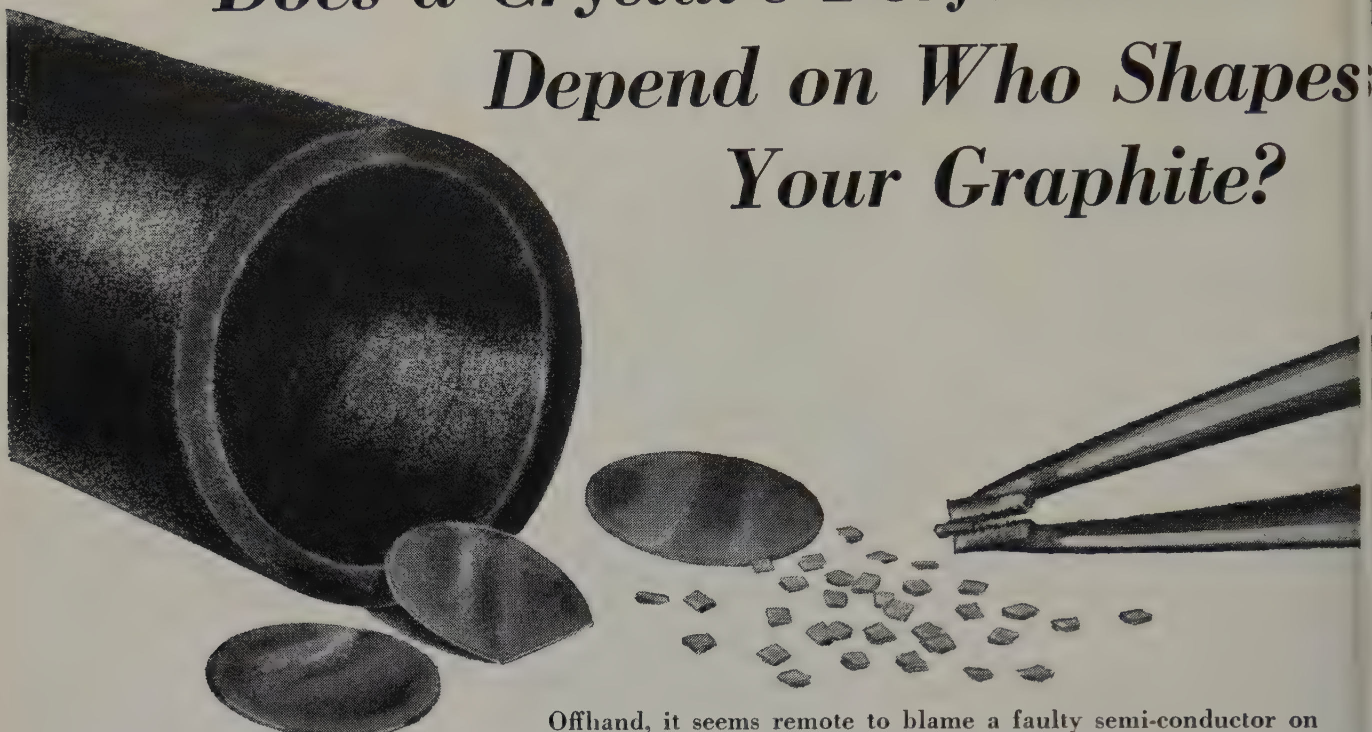
It is safe to assume that the Hall effect will play an increasing role in future technical applications.

Correction

In Dr. Minden's article, "Intermetallic Semiconductors," February 1959, page 33, figure 3, the part of the caption which reads "the different values of s/1 represent the ratio of width to length of the specimen," should read "the different values of s/1 represent the ratio of the dimensions of the Hall current electrodes to the length of the bar."

Samuel L. Marshall

Does a Crystal's Performance Depend on Who Shapes Your Graphite?



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Avalanche Noise In P-N Junctions

S. SHERR* and S. KING*

Several investigators have reported the existence of a unique type of noise when a *p-n* junction diode is operated at the onset of the avalanche region. The character of the noise is investigated in detail, and a physical theory is presented which correlates this noise to various attributes of the *p-n* junction. The use of the diode as a flat noise source is explored to a limited extent, with the physical theory as a guide to the selection and design of a device for this purpose.

THE PHENOMENON of abrupt breakdown of a *p-n* junction when biased in the reverse direction was first reported in 1951.[1] At this time the phenomenon was considered to be due to field effects and the theoretical formulations of Zener were extended by Shockley[1] to provide a basis for understanding this action. As a result the breakdown voltage was termed the Zener voltage, and the devices designed to capitalize on the effect were termed Zener diodes. Some of the subsequent literature[2] on this subject mentioned the deviations found in practice from the theory, but dismissed them as due to manufacturing defects rather than to inadequacies in the theory.

One of the unexplained effects was the noise which appeared in certain diodes when operated around the knee or low current region of the so called Zener characteristic. No satisfactory explanation of this noise was found until McKay,[3] in his pioneering paper, demonstrated that a different type of breakdown, which he termed avalanche breakdown occurred in some of the diodes which he investigated. His explanation is now generally accepted and Shockley has acknowledged the previous misnomer.† Unfortunately the designation has become somewhat entrenched, and Zener is still used to describe devices which operate due to the avalanche effect. We shall use the terms in their correct connotation, and define below a criterion for determining whether Zener or avalanche breakdown is occurring.

While McKay supplied a good qualitative description of the cause and character of the noise, further investigation of this type of junction noise has been sparsely reported,[4, 5] with most noise studies dealing with other regions,[6, 7] and either dismissing or ignoring this small but significant region of noise production. Our interest in this phenomenon developed from a general survey of a variety of noise sources which we conducted with the view of finding those which contained certain specific characteristics. We eventually concentrated on the avalanche region noise, and our measurements and experiments have shown it to be large in magnitude, essentially flat in amplitude *vs.* frequency over wide bands, and relatively insensitive to variation of bias current over the range in which the noise exists.

An interesting characteristic of the noise, which should be mentioned before proceeding to the descriptions of theory and experiments, is that it is oscillatory in nature. While this perhaps precludes the exact use of the word noise, in the most accurate sense, our results show that over the band of frequencies below the oscillation frequencies, all the necessary characteristics of noise do exist. We also demonstrate below that the effect is related to the onset of the avalanche region, and that the frequencies have numerical values which are clearly functions of the voltage at which avalanche breakdown occurs. These oscillations tend to be random in amplitude and phase producing true white noise over a wide band below the specific frequency, and it is on this basis that we have used the phrase "Avalanche Noise" in describing the phenomenon.

Theoretical Considerations

McKay,[3] in his description of the noise refers to it as clipped, and made up of current pulses through the junction. He also notes that the pulse lengths and distances between pulses vary in a random manner. His interpretation of his observations is that they reflect an unstable breakdown of various regions of the junction. He is clearly dealing with the oscillatory type of noise which we have mentioned, and does not extend his observations into the regions where true noise exists. Following McKay in his description of this noise, we also state that the noise appears at the onset of breakdown, and that it consists of current pulses through the junction. However, we predicate that the

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†See Semiconductor Products, Mar./Apr. 1958, p. 5.

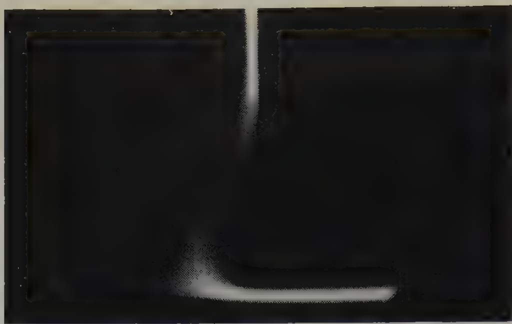


Fig. 1—Voltage—Current characteristic. (12 volt diode)

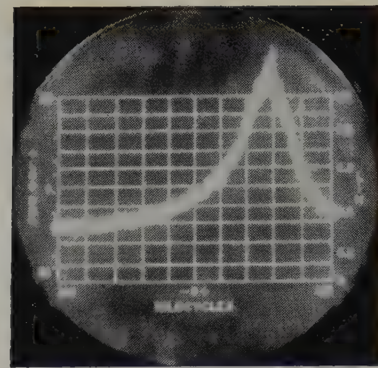


Fig. 2—Noise spectrum, 114 volt diode. (0-200 kc.)

noise mechanism is based on the presence of a junction time constant and a negative resistance region in the voltage-current characteristic of the diode. These factors in association with three voltages, V_B, V_A, and V_{bb}, determine both the existence and repetition rate of the oscillatory discharge.

where V_{bb} = charging voltage across the diode
V_B = voltage across the diode at onset of breakdown
V_A = voltage across the diode to sustain breakdown

In this respect, we compare the junction avalanche noise to that existing in a thyratron gas tube,[8] such as the 6D4. *Fig. 1* is a photograph of the voltage-current characteristic of a representative junction diode which shows this negative resistance region with the noise throughout the region, while *Fig. 2* is a photograph of the noise spectrum itself, exhibiting peaking at one specific frequency.

If we examine the formula for ionization rate,

$$\alpha_i\,(E_M) = \frac{2}{W_1^2}\,\frac{d(1-1/M)}{dE_M} - \frac{4}{W_1^3}\,(1-1/M)\,\frac{dW_1}{dE_M} \qquad (1)$$

where α_i = ionization rate
E_M = maximum field in junction
W_1 = width constant for given step junction
M = multiplication factor

derived by McKay for the step junction, we may conclude that the ionization rate along the junction will vary if the junction width and resistivity of the material is not uniform. In addition, using the empirically determined proportionality[3]

$$V_A \approx K_1 \rho^{+N} \qquad (2)$$

where ρ = junction resistivity
K_1 = arbitrary constant

for diffused *p-n* junctions, we can determine that any variability in uniformity of resistivity will cause non-uniform onset of breakdown along the junction. However, each breakdown area will be well defined, though initially not self-maintaining, since the increase of carriers at the breakdown point will reduce the junction gradient below the level required for avalanche multiplication, without providing enough carriers for sustained breakdown. Under these conditions, we may anticipate that narrow junction areas will exhibit higher frequency relaxations and biasing ranges for this noise production than wide junctions will. Also, while the period of each individual relaxation in the various breakdown areas will be in the same order, a range of frequencies will be encountered which will be in random amplitude and phase relation, thus accounting for the wide band noise which exists below the basic range of relaxation frequencies. Finally, wider junctions will have lower frequencies of oscillation but larger voltage amplitudes, due to the greater opportunity to collect carriers and the wider voltage differential between V_A and V_B.

The relative frequency of relaxation may be computed by utilizing the formulas which relate V_A to ρ and junction capacity. Equation 2 is one relationship while[5]

$$V_A \propto K_2 C^{-N} \qquad (3)$$

where C = junction capacity
K_2 = arbitrary constant

is the second form. We now postulate that

$$F = f\,[(V_B - V_A),\, C_j,\, R_j] \qquad (4)$$

where F = frequency of oscillation.

This is in conformance with the previous statement that the oscillation frequency is determined by the factors listed in Equation 4. The explicit form may be derived by referring to *Fig. 3* and writing the usual equation for voltage in an *RC* circuit. In this case the equation is

$$V_B = (V_{bb} - V_A)\,(1 - e^{-t/R_j C_j}) + V_A$$

Assuming $t/_{R_j C_j} \ll 1$ this reduces to

$$V_B \approx [(V_{bb} - V_A)\,t/R_j\,C_j] + V_A$$

which then may be solved explicitly for t.

$$t \approx R_j\,C_j\,(V_B - V_A)/(V_{bb} - V_A) \qquad (5)$$

where R_j = junction resistance
C_j = junction capacitance
t = $1/F$

Using the formulas and empirical data it is possible to calculate relative frequencies with reasonable accu-

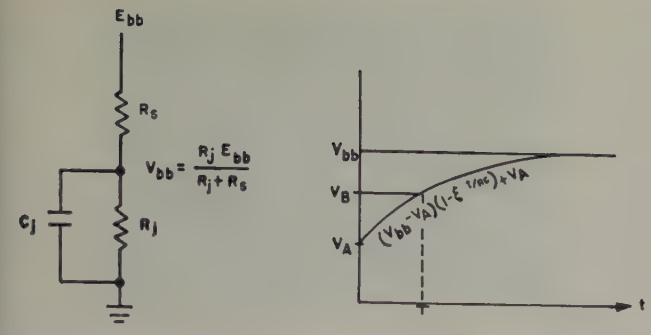


Fig. 3—Simplified equivalent circuit and voltage across diode *vs.* time.

RMS Noise Output of Various Diodes

TABLE I

Approximate V_B in volts	RMS Noise Output in Millivolts (Ballantine True RMS Meter)
6	Too small to measure
8	2.5 to 15
9	10
11	.8 to 120
12	1.2 to 140
24	600 to 760
48	76 to 600
55	600
90	800 to 2000
110	700 to 4000

racy and use these results as a check of the relaxation oscillation theory.

The expected temperature variation is a decrease in noise with increasing temperature related to decrease in $V_B - V_A$ caused by the increase in ionization rate. All these theoretical predictions are supported by the experimental data presented below. In addition, the evidence that avalanche breakdown does not occur below 6.5 volts as reported elsewhere,[9] is supported by the absence of avalanche noise in all diodes which exhibited $V_B < 7$ volts.

Experimental Verification

A large number of diodes from different manufacturers, with voltage ratings varying from 3 to 115 volts were examined for the existence of avalanche noise. The techniques used in determining the character of the noise spectrum are described in detail elsewhere.[10] A sufficient description of these techniques for our purposes is to say that they consist of examining the spectra by means of a specially calibrated and adjusted spectrum analyzer. By properly choosing the detector time constant, scanning width, filter band width and sweep time, meaningful photographs of the visual display may be taken. *Fig. 2* is a representative sample. The paper referred to completely describes the calibration and design requirements for this method of examining and recording noise spectra.

The relaxation character of representative types at various voltages is shown in *Fig. 4*. It should be noted that the basic frequency is clearly a function of $(V_B - V_A)$ (the amplitude of oscillations). Static voltage-current characteristics for several diodes are plotted in *Fig. 5*. There was wide variability observed in the noise output amplitude, which is essentially proportional to the size of the negative resistance region, as will be shown later. Table I lists maximum and minimum values of noise output observed on various units. All low voltage diodes (i.e. $< 7.5v$) show no noise or negative resistance, but exhibit the "soft" knee characteristics of true Zener breakdown. The units with lowest noise voltages have been considered to have most uniform resistivity, most parallel junctions and exhibit the narrowest negative resistance region.

To demonstrate the corroboration of the results of the various tests, the data on two diodes is presented below. We chose diodes with $E_B \approx 12$ volts and $E_B \approx 114$ volts. The test circuit used is shown in *Fig. 6*.

Because of the series resistor R_S, the equation for the relaxation period t becomes:

$$t \approx \frac{R_j\, R_S}{R_j + R_S}\, C_j\, \frac{V_B - V_A}{\dfrac{R_j\, E_{bb}}{R_j + R_S} - V_A} \qquad (6)$$

Using measured values for C_j, R_j, V_A, $(V_B - V_A)$ and R_S the following results were obtained:

12 volt unit: $C_j = 75\ \mu\mu fd.$, $R_j \approx 275K$, $E_{bb} = 60$ volt, $V_B - V_A \approx .05v$, $R_S = 1$ megohm.

$$t \approx 75 \times 10^{-12} \times 215 \times 10^{3} \times \frac{.05}{13 - 12} = .8\ \mu\text{sec}$$

Fig. 4—Relaxation oscillations for various diodes. 60 V. unit, 0.2 V/cm, 1 μsec/cm, is shown at the left; a 100 V. unit, 0.5 V/cm μsec/cm, in the center; and a 12 V. unit, .005 V/cm, .1 μsec/cm, at the right.

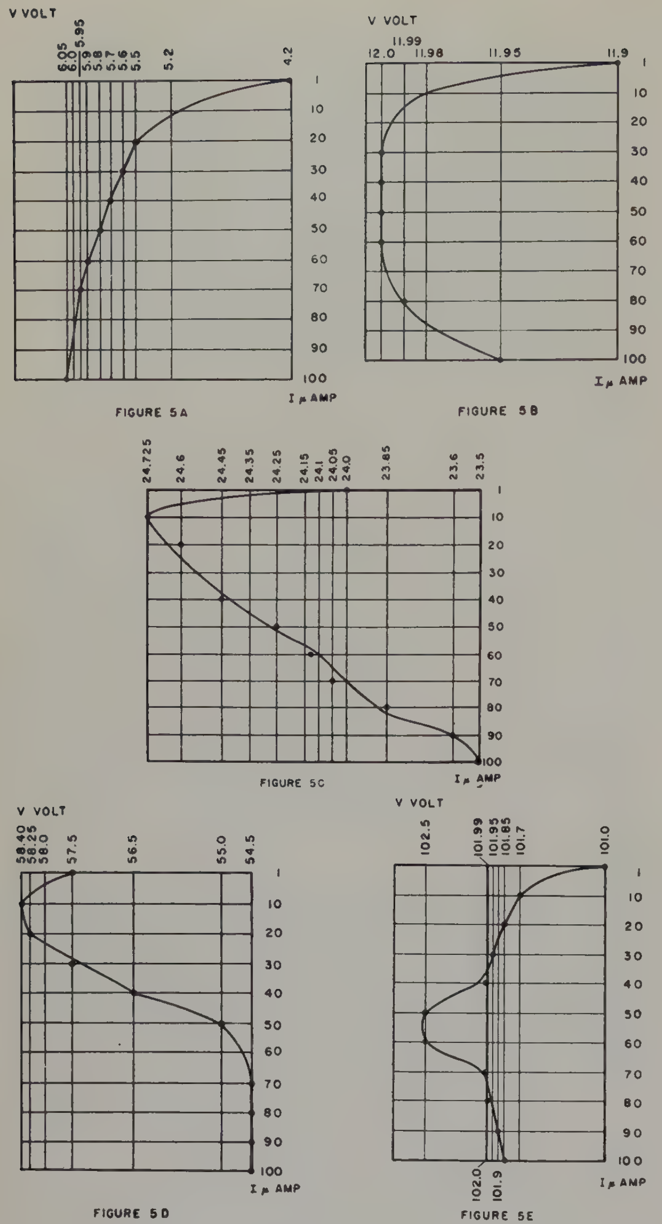


Fig. 5—Static V-I characteristics. (a) 6 volt unit; (b) 12 volt unit; (c) 24 volt unit; (d) 55 volt unit; (e) 100 volt unit.

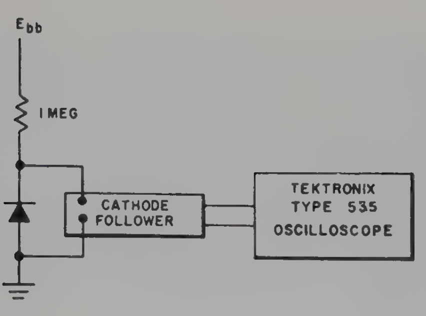
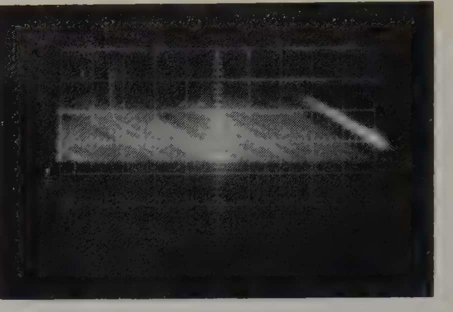


Fig. 6—Test circuit used for experimental verification.

114 V Unit, 0.5 V/cm, 5 μsec/cm



12 V. Unit, .02 V/cm, .2 μsec/cm

Fig. 7—Relaxation oscillations for 12 and 144 volt units.

114 volt unit: $C_j = 7\ \mu\mu fd$, $R_j = 18.5$ meg, $E_{bb} = 120v$, $V_B - V_A = .7v$.

$$t \approx 7 \times 10^{-12} \times 10^{5} \times \frac{.7}{114 - 113.3} = 7\ \mu\text{sec}$$

It can be seen that R_j varies with the current through the diode and it is difficult to determine the exact value to be used in Equation 6.

Figure 7 shows the relaxation oscillations of the two diodes. Reading the highest period gives results of .6 μsec. for the 12 volt unit and 10 μsec. for the 114 volt unit, which is in reasonable agreement with the values calculated above. Paralleling the diodes with a capacitor of value C_j doubled the period of observed oscillations. Variations in R_S produced frequencies of oscillation which checked with the results from Equation 6.

Figure 8 shows static voltage-current characteristics of these diodes. It can be seen that the negative resistance region in the 12 volt unit extends through 80 millivolts which compares well with $V_B - V_A =$ 50 millivolts measured previously. The 114 volt unit has a large negative resistance region.

The noise output of these diodes was measured on a "True *RMS* Meter" with readings of 50 millivolts and 1.54 volts for the 12 volt and 114 volt units respectively. For the high voltage unit, the loading presented by the *d*-c and *a*-c measuring equipment is comparable, and is significant for determining absolute values. However, for comparison, this loading may be neglected, and the measured value used. The temperature variability of noise output for the 12 volt

unit is shown in Table II. It can be seen that the expected variations predicted by the theory do occur and that this affords good empirical corroboration of the theoretical mechanisms presented.

Conclusion

A theory of avalanche discharge and the negative resistance characteristic has been presented for diodes operated at the onset of the avalanche region. It has been shown that this theory explains the existence of oscillatory type relaxation discharge and permits the calculation of actual or relative frequency of discharge. Because of the multiple discharge points along the junction, a random frequency and phase condition exists in this discharge, which provides a band of essentially flat noise in the region below the frequency of oscilliation. The noise amplitude is a function of the breakdown voltage, and may be determined by examining the extent of the negative resistance region. It is anticipated that this noise amplitude may be minimized by maintaining uniform junction width and resistivity. The soft knee characteristic of the low-voltage diode is corroborated, as is the Chynoweth and McKay conclusion,[9] that no avalanche multiplication occurs in diodes below 7 volts. Finally, it is shown that the oscillatory discharges and associated noise spectra are of the same form for all diodes in the voltage range above 7 volts, and may be predicted and controlled by the techniques described above.

TABLE II

Temperature Dependence of RMS Noise Output

Temperature °C.	RMS Millivolts
25°	50
70°	38
82°	35.8
88°	35
125°	22.8

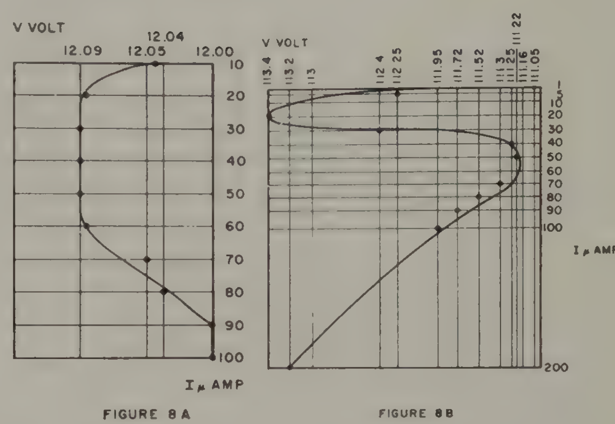


Fig. 8—Static V-I characteristics. (a) 12 volt unit; (b) 114 volt unit.

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An Analysis of Impurity Distributions and Their Relation to Electrical Behavior of Conventional Transistor Constructions

DR. PETER KAUFMANN* and GEORGE FREEDMAN**

PART 2

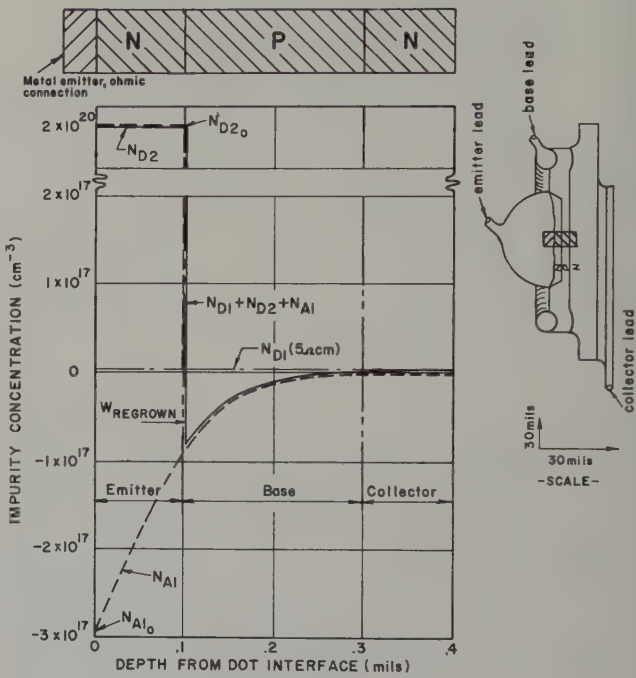
In Part 1 of this article, design concepts in transistor fabrication were discussed, and an "ideal" or "most versatile" impurity distribution was hypothesized. Four of the ten most common real distributions were calculated and related to the ideal. In this, the conclusion of the article, the remaining six distributions are dealt with. Finally, the performance qualities of each type are summarized in tabular form.

E. The Alloy-Diffused Transistor [24] [32]†

In this approach (*Fig. 7*), the emitter junction follows the segregation law while the base profile and collector junction are created in accordance with the diffusion principle. Transistors of this type have inherently good high-frequency qualities, except that the collector capacitance is a problem, at least in the conventional geometry. Fabrication of power devices by this method is critical since alloying tends to follow the crystal plane and diffusion does not. For large area emitters, therefore, extremely good crystal orientation is required. As in all transistors fabricated from only one side, the saturation resistance is potentially high. No opposing field in the base region is encountered, since the emitter alloying process generally takes place at much lower temperatures than the diffusion and is a "short" time process. Non-penetrating emitters would give large aiding fields in the base region.

F. Alloyed Diffused Intrinsic Region Transistor [11] [21]

An alloyed diffused device which approximates the ideal geometry is the "intrinsic region" transistor (*Fig. 8*). In this device, both emitter and collector junctions are obtained by alloying while the base grading is provided by diffusion. A compromise between high collector capacitance and low minimum collector-to-base voltage must be effected by careful design of the intrinsic region. Relatively tight manufacturing control of resistivity, chip thickness, diffusion depth and dot penetration is also required. Adaptation of this unit as a power device presents even more specialized problems than the alloyed diffused unit. However, the intrinsic region unit incorporates most of the advantages of the "ideal" transistor



Processing assumptions:

Bulk impurity concentration: $N_{D1} = 3 \times 10^{14}$ atoms/cm^3
Vapor diffusion of acceptor impurity (gallium) into bulk
Diffusion temperature: 840 °C.
Diffusion time: 1 hour
Diffusion coefficient: 8×10^{-12}
Surface concentration: $N_{A1_0} = 3 \times 10^{17}$ atoms/cm^3
Alloying of dot containing donor impurity (arsenic)
Interface concentration: $N_{D2_0} = 2 \times 10^{20}$ atoms/cm^3

Calculation assumptions:

Acceptor density: $N_{A1} = N_{A1_0}\, erfc \dfrac{x}{2\sqrt{D_{Ga}\, t}}$
Donor density: N_{D1} = constant
and $N_{D2} = k\, N_{D2_0}\,(1-g)^{k-1}$
Segregation coefficient: $k \cong 1$

Resultant profile:

$N_{D1} + N_{A1} + N_{D2}$

Fig. 7—Alloyed diffused transistor. (n-p-n germanium)

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†See "References" and "List of Symbols," p. 31.

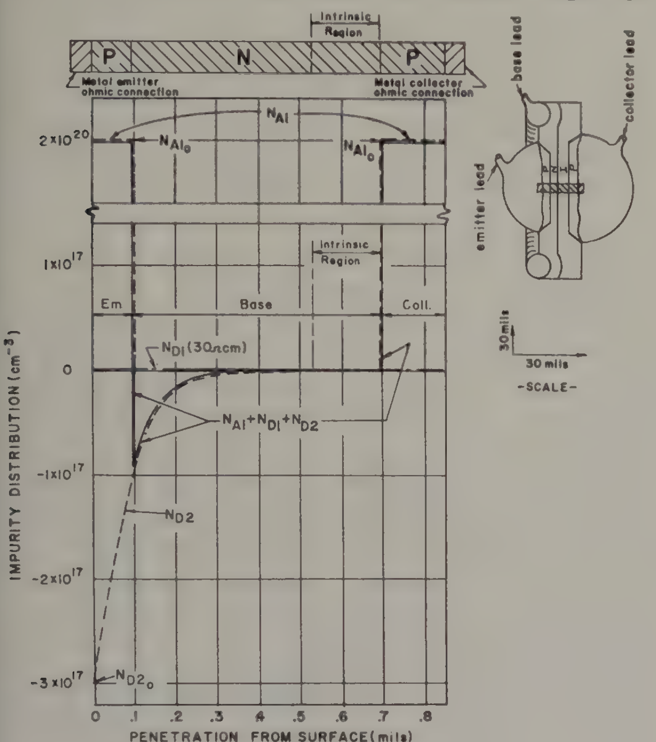
as described earlier, e.g. high punch-through and breakdown voltages, low saturation voltage, etc.

G. The Grown Transistor [40] [41]

This is a typical example (*Fig. 9*) in which the profile has to be accepted as nature gives it to us, since solid-state diffusion takes place during the growing process (which would otherwise involve only the segregation principle). This diffusion rounds off the corners of the profile, making the junctions less abrupt.

The low impurity gradient of the collector is advantageous because it decreases the collector capacity. The low gradient of the emitter, however is a disadvantage, as mentioned previously. In the calculation, the diffusion coefficients have been assumed constant throughout the growing process. This is, in practice, not completely accurate since a thermal gradient exists in the direction of the growth, which alters the diffusion constants. The transistor manufacturer tries to decrease this gradient as much as possible, in order to obtain good crystal perfection.

It is obvious that this device will have inherently high extrinsic collector resistance (high saturation



Processing assumptions:

Bulk impurity concentration: $N_{D1} = 5 \times 10^{13}$ atoms/cm³

Vapor diffusion of donor (arsenic) into bulk

Diffusion temperature: 740 °C.

Diffusion time: 1.1 hours

Diffusion coefficient: 8×10^{-12} cm²/sec.

Surface concentration: $N_{D2_o} = 3 \times 10^{17}$ atoms/cm³

Alloying of dots containing acceptor impurity (gallium) (rapid cooling)

Interface concentration: $N_{A1_o} = 2 \times 10^{20}$ atoms/cm³

Calculation assumptions:

Cylindrical dots $\left(g = \dfrac{x}{W_{regrown}}\right)$

Acceptor density:

$$N_{A1} = k\, N_{A1_o}(1-g)^{k-1} = \begin{cases} 2\times10^{20}\text{ atoms/cm}^3 & \begin{cases}(x<0.1)\\(x>0.7)\end{cases} \\ 0 & (0.1<x<0.7)\end{cases}$$

Segregation coefficient: k = 1

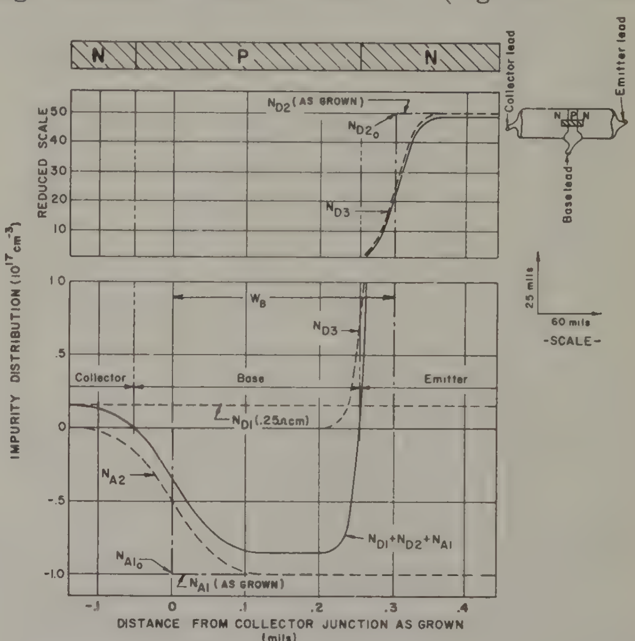
Donor density: N_{D1} = constant

$$\text{and } N_{D2} + N_{D2_o}\, erfc\, \frac{x}{2\sqrt{D_{As}\, t}}$$

Resultant profile:

$N_{D1} + N_{A1} + N_{D2}$

Fig. 8—Alloyed diffused intrinsic region transistor. (p-n-i_n-p germanium)



Processing assumptions:

Bulk impurity concentration: $N_{D1} = 1.5 \times 10^{16}$ atoms/cm³

Crystal growth rate: 0.28 mils/sec.

Acceptor impurity (indium) added directly to n-type melt

Interface concentration: $N_{A1_o} = 10^{17}$ atoms/cm³

Donor impurity (antimony) added after 2-second time lag

Interface concentration: $N_{D2_o} = 5 \times 10^{18}$ atoms/cm³

Simultaneous bulk diffusion from both interfaces

Diffusion temperature: 1400 °C.

Diffusion time: 200 seconds

Diffusion coefficients: $D_{In} = 4 \times 10^{-11}$ cm²/sec. and $D_{Sb} = 8 \times 10^{-12}$cm²/sec.

Calculation assumptions:

Constant cross-sectional area $\left(g = \dfrac{x - constant}{W_{grown}}\right)$

Acceptor density:

$$N_{A1} = \begin{cases} k\, N_{A1_o}(1-g)^{k-1} & (x>0) \\ 0 & (x<0)\end{cases}$$

$$N_{A2} = \frac{N_{A1_o}}{2}\left[2 - erfc\, \frac{x}{2\sqrt{D_{In}\, t}}\right]$$

Segregation coefficient: $k \cong 1$

Donor density: N_{D1} = constant

$$N_{D2} = \begin{cases} kN_{D2_o}(1-g)^{k-1} & (x>0.3) \\ 0 & (x<0.3)\end{cases}$$

$$N_{D3} = \frac{N_{D2_o}}{2}\left[2 - erfc\, \frac{x-0.3}{2\sqrt{D_{Sb}\, t}}\right]$$

Segregation coefficient: k $\cong$ 1

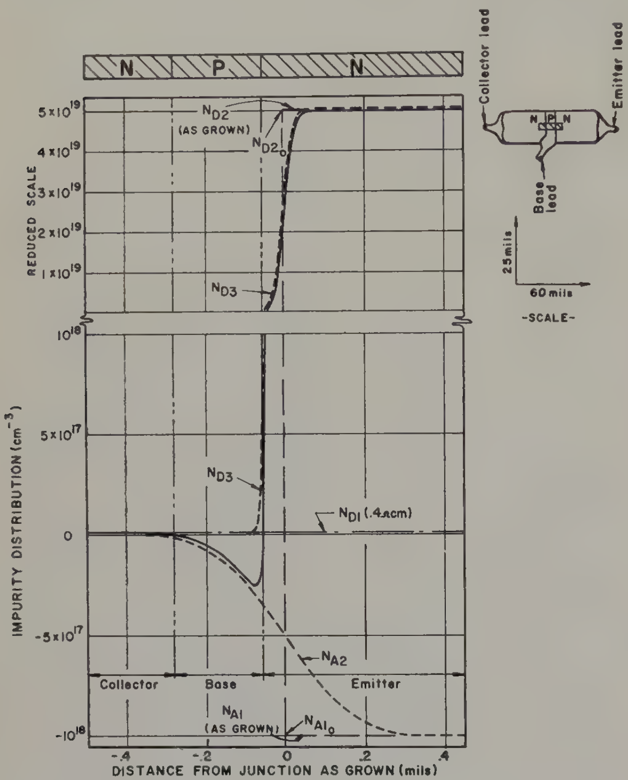
Resultant profile:

$N_{D1} + N_{A2} + N_{D3}$

Fig. 9—Grown transistor. (n-p-n silicon)

voltage) because the collector doping must be sufficiently low to allow base and emitter over-doping.

The next three transistor types make use of the concept of bulk-diffusion; that is, subsequent to the formation of emitter and collector zones, a base region is formed by diffusion from one solid region into another. The double diffused process previously described differs in that the impurity source is of vapor form rather than solid. This bulk diffusion phenomenon has already been encountered in the grown transistor where it is considered more of a nuisance than an advantage.



Processing assumptions:

Bulk impurity concentration: $N_{D1} = 10^{16}$ atoms/cm³

Crystal growth rate: 0.28 mils/sec.

Simultaneous addition of acceptor impurity (aluminum) and donor impurity (arsenic) to n-type melt

Simultaneous bulk diffusion of both impurities from interface

Diffusion temperature: 1400 °C.

Diffusion time: 200 seconds

Diffusion coefficients: $D_{Al} = 3 \times 10^{-10}$ cm²/sec. and $D_{As} = 8 \times 10^{-12}$ cm²/sec.

Calculation assumptions:

Constant cross-sectional area $\left(g = \dfrac{x}{W_{grown}} \right)$

Acceptor density:

$$N_{A1} = \begin{cases} 0 & (x < 0) \\ k\, N_{A1_o} (1 - g)^{k-1} & (x > 0) \end{cases}$$

$$N_{A2} = \frac{N_{A1_o}}{2} \left[2 - erfc \frac{x}{2\sqrt{D_{Al}\, t}} \right]$$

Segregation coefficient: $k \cong 1$

Donor desnity:

$$N_{D2} = \begin{cases} 0 & (x < 0) \\ k\, N_{D2_o} (1 - g)^{k-1} & (x > 0) \end{cases}$$

$$N_{D3} = \frac{N_{D2_o}}{2} \left[2 - erfc \frac{x}{2\sqrt{D_{As}\, t}} \right]$$

Segregation coefficient: $k \cong 1$.

Resultant profile:

$N_{D1} + N_{A2} + N_{D3}$

Fig. 10—Grown diffused transistor. (n-p-n silicon)

H. Grown Diffused [6] [37]

A high-frequency transistor with a profile relatively similar to that of the double-diffused device can be fabricated by introducing both impurity types into the melt at the same time. This device, pictured in *Fig. 10,* shows a base zone made by solid-state diffusion. The diffusion proceeds from the emitter side during a programmed pause in the cooling cycle, at a temperature somewhat below the freezing point. The calculation of the diffusion profile again assumes a constant diffusion coefficient. Therefore, the actual profile differs slightly from the one shown, since the slopes of the impurity curves are in reality steeper. The main feature of this unit is its very narrow base width and potentially low collector capacitance.

I. Alloyed Bulk Diffused [3] [4] [14]

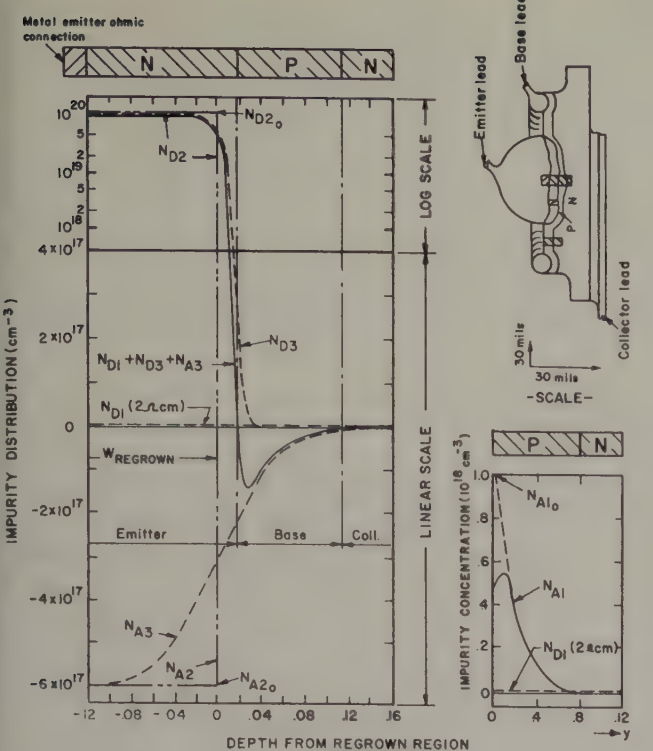
A very versatile profile is shown for the alloyed bulk diffused transistor (*Fig. 11*) in which out-diffusion of the alloyed (segregated) emitter region creates the base region and the collector junction. A narrow base region of constant width can be expected from such a technique; therefore, many of the difficulties inherent in the alloyed-diffused and other approaches are not encountered. The profile is quite similar to the one for the double-diffused transistor, except that an alloyed region exists behind the diffused portion of the emitter (adjacent to the metal contact); hence emitter efficiency problems are minimized. This technique is quite versatile, since the reservoir concentrations for the diffusions are controlled by the amounts of doping elements. The attainment of a desired diffusion profile is not critical if the diffusion constant of the emitter impurity is much lower than the one of the base impurity (a situation easily obtained with the common impurity elements for the cases of n-p-n silicon and p-n-p germanium transistors).

The extrinsic base resistance is primarily controlled by a previously diffused region (N_{A1}) for which maintenance of close tolerances of processing conditions is not essential. As shown in *Fig. 11,* there is a slight slumping of N_{A1} due to the alloy diffusion process. It should be noted that for this construction it is possible to create the base region from a molten emitter dot as well as from the regrown emitter but for the example shown, only the solid-solid case is considered.

The penetrating alloyed collector connection decreases the extrinsic collector resistances for this type as it would for several other constructions.

J. Diffused Meltback [29]

If the diffusion constants for the acceptor and donor elements are chosen properly in the meltback case, impurities can be diffused out of the unmelted emitter region into the low impurity level sink, forming a base region and collector junction. *Fig. 12* shows such a



Processing assumptions:

Bulk impurity concentration: $N_{D1} = 2 \times 10^{15}$ atoms/cm³

Vapor diffusion of acceptor impurity (gallium) into bulk

Diffusion temperature: 1225 °C.

Diffusion time: 8 hours

Diffusion coefficient: 5.8×10^{-12} cm²/sec.

Surface concentration: $N_{A1_o} = 10^{18}$ atoms/cm³

Alloying of dot containing acceptor impurity (aluminum) and donor impurity (arsenic)

Interface concentrations: $N_{A2_o} = 6 \times 10^{17}$ atoms/cm³ and $N_{D2_o} = 10^{20}$ atoms/cm³

Simultaneous bulk diffusion of both impurities from interface

Diffusion temperature: 1150 °C.

Diffusion time: 1.7 hours

Diffusion coefficients: $D_{Al} = 5.5 \times 10^{-12}$ cm²/sec. and $D_{As} = 1.1 \times 10^{-13}$ cm²/sec.

Calculation assumptions:

Cylindrical dots $\left(g = \dfrac{|x|}{W_{grown}}\right)$

Acceptor density: N_{A1} = modification of $N_{A1_o}\, erfc\, 2\dfrac{y}{\sqrt{D_{Ga}\, t_{Ga}}}$ allowing for slump effect resulting from subsequent diffusion.

$$N_{A2} = \begin{cases} k\, N_{A2}\,(1-g)^{k-1} & (x<0) \\ 0 & (x>0) \end{cases}$$

$$N_{A3} = \frac{N_{A2_o}}{2}\, erfc\, \frac{x}{2\sqrt{D_{Al}\, t}}$$

Segregation coefficient: $k \cong 1$

Donor density: N_{D1} = constant

$$N_{D2} = \begin{cases} k\, N_{D2_o}\,(1-g)^{k-1} & (x<0) \\ 0 & (x>0) \end{cases}$$

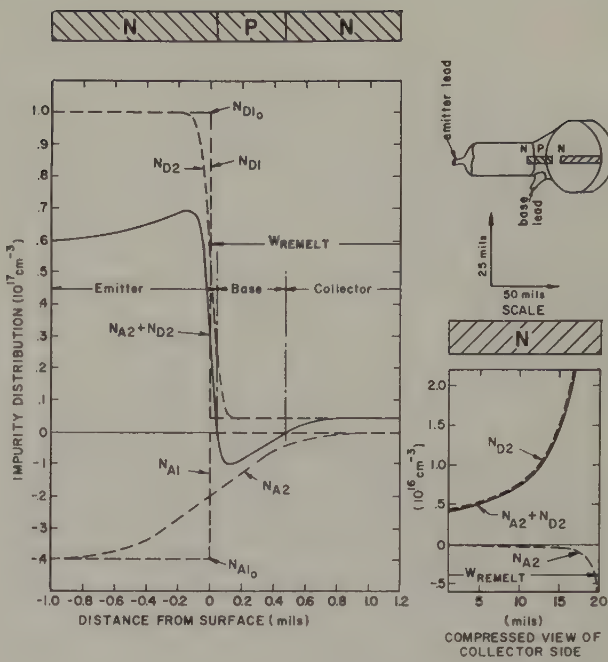
$$N_{D3} = \frac{N_{D2_o}}{2}\, erfc\, \frac{x}{2\sqrt{D_{As}\, t}}$$

Segregation coefficient: $k \cong 1$

Resultant profile:

$N_{D1} + N_{A3} + N_{D3}$

Fig. 11—Alloyed bulk diffused transistor. (n-p-n silicon)



Processing assumptions:

Original bulk impurity concentration:

$N_{A1_o} = 4 \times 10^{16}$ atoms/cm³ and $N_{D1_o} = 10^{17}$ atoms/cm³

Rapid crystal growth — melt containing acceptor impurity (aluminum) and donor impurity (antimony)

Meltback and recrystallization

Simultaneous bulk diffusion of acceptor and donor impurities

Diffusion temperature: 1300 °C.

Diffusion time: 1.55 hours

Diffusion coefficients: $D_{Al} = 8 \times 10^{-11}$ cm²/sec. and $D_{Sb} = 1.5 \times 10^{-12}$ cm²/sec.

Calculation assumptions:

Constant cross-sectional area $\left(g = \dfrac{x}{W_{remelt}}\right)$

Acceptor density:

$$N_{A1} = \begin{cases} N_{A10} & (\text{since } k_{Al} \cong 1) \quad (x<0) \\ k_{Al}\, N_{A1_o}\,(1-g)^{k_{Al}-1} & (x>0) \end{cases}$$

Segregation coefficient: $k_{Al} = 0.003$

$$N_{A2} = \begin{cases} \dfrac{N_{A1}(0-) - N_{A1}(0+)}{2}\, erfc\, \dfrac{x}{2\sqrt{D_{Al}\, t}} & (x<0) \\ N_{A1} + \dfrac{N_{A1}(0-) - N_{A1}(0+)}{2}\, erfc\, \dfrac{x}{2\sqrt{D_{Al}\, t}} & (x>0) \end{cases}$$

Donor density:

$$N_{D1} = \begin{cases} N_{D1_o} & (\text{since } k_{Sb} \cong 1) \quad (x<0) \\ k_{Sb}\, N_{D1_o}\,(1-g)^{k_{Sb}-1} & (x>0) \end{cases}$$

Segregation coefficient: $k_{Sb} = 0.04$

$$N_{D2} = \begin{cases} \dfrac{N_{D1}(0-) - N_{D1}(0+)}{2}\, erfc\, \dfrac{x}{2\sqrt{D_{Sb}\, t}} & (x<0) \\ N_{D1} + \dfrac{N_{D1}(0-) - N_{D1}(0+)}{2}\, erfc\, \dfrac{x}{2\sqrt{D_{Sb}\, t}} & (x>0) \end{cases}$$

Resultant profile:

$N_{A2} + N_{D2}$

Fig. 12—Diffused meltback transistor. (n-p-n silicon)

Table II

Potential Electrical Performance Appraisal of Impurity Profiles *

Type	α_{fe}	$r_{b\ extr.}$	C_c	f_{ab}	V_p	BV_{CB}	V_{SAT}	V_{min}
Fusion Alloy	A	B	C	C	C	B	A	A
Diffused Emitter and Collector	B	B	B	C	C	B	A	A
Meltback	C	B	B	B	C	B	B	A
Emitter and Base Diffused								
(a) simultaneously	C	B	B	B	B	A	C	A
(b) sequentially	C	B	B	B	B	A	C	A
Alloy Diffused	A	A	B	A	A	A	C	A
(Alloyed) Intrinsic Region	A	A	A	A	A	B	B	C
Grown	B	B	B	C	C	A	C	A
Grown Diffused	A	B	B	A	B	A	C	A
Alloy Bulk Diffused	A	A	B	A	B	A	C	A
Diffused Meltback	B	B	B	A	B	B	B	A

*Note: In this table "A" is meant to indicate best, "B" medium, and "C" least desirable.

unit, made by a slow refreezing process. Due to the low segregation constants chosen in the example, the collector necessarily has a high resistivity over a wide region.[9] The device as illustrated indicates potentially good f_{ab} and C_c, but the emitter efficiency is again limited.

Comparison of Actual Transistor Profiles with the "Ideal"

Of the ten basic impurity profiles given here, the alloyed intrinsic region transistor most closely approaches the "most versatile" impurity distribution. Five types: the double diffused, alloyed diffused, alloyed bulk diffused, grown diffused, and meltback diffused have many features in common with the ideal. Four types: the grown, fusion-alloy, meltback and diffused emitter and collector differ more from the ideal.

The difference between the alloyed intrinsic region transistor and the ideal is a very tangible and serious one. It is caused by the difficulty at this time of achieving a really pure intrinsic zone within a device. This difficulty is even more pronounced in silicon than in germanium. As a result of this situation, there is an unavoidable threshold voltage (V_{min}) which must be exceeded before the transistor will operate effectively in many applications. (In present germanium units, V_{min} is generally in excess of 3 volts.) Thus the user of this commercial device is faced with choosing between the advantage of low C_c and the disadvantage of the introduction of the threshold voltage difficulty. The low C_c advantage has been chosen in this case. For the nine remaining profiles the threshold voltage problem does not exist.

The group of transistors built around the profiles for double diffused, alloyed diffused, alloyed bulk diffused, grown diffused and meltback diffused resemble the ideal case, primarily because they all have similar graded base impurity distributions, a factor which greatly aids such performance parameters as V_p, $r_{b\ extr}$, f_{ab}, etc.

One could minimize the remaining differences which exist between this group and the ideal transistor concept by designing some compromise features into the diffused-base family. Thus, introduction of an intrinsic region and a fused collector dot results in new profiles which deviate only slightly from the ideal case. The alloy diffused, alloy bulk diffused and double diffused transistors are more amenable to this kind of construction modification than the grown diffused or the meltback diffused.

The fact that the remaining four impurity profiles differ from the ideal case to a greater degree does not make them poor transistors. Rather it points out that they are engineered for a more limited range of application. In point of fact, more transistors made by the fusion-alloy and grown techniques have been put into service than transistors made by all other techniques combined.

The preceding discussion leads to the following conclusions:

1. The "ideal" transistor profile is a useful analytical concept which aids in understanding the present range of available transistors.
2. Achievement of the ideal profile would be very desirable; however, this does not appear to be practicable at this time.
3. The different impurity profiles approach the ideal in varying degrees and could come closer with the introduction of several compromise features, if this should be considered desirable and economical.
4. Transistors that deviate greatly from the ideal can be perfectly adequate for many important circuit applications.

Tabulation of Performance Qualities

The final summary of this article is to be found in Table II. The user of this table should realize that it is an attempt to appraise only theoretical limitations and advantages of impurity distributions (*Figs. 2* through *12*). This appraisal was necessarily made in a way which is quite qualitative and dependent on the judgment of the writers.

While, in general, the electrical performance picture for available transistors matches the theoretical expectations, many differences exist where the engineer-

[9]The collector will have a low resistivity near the collector-base junction if an increasing speed of growth is assumed as in the case of the meltback transistor.

ing art has progressed nearer to the theoretical limits for some devices than for others.

It should be understood that new applications could call for different impurity profiles and a different "ideal" in conventional transistors. Other concepts such as tetrodes, hook transistors, field effect transistors, unipolar transistors and the newer ones, such as thyristors, spacistors, etc., may be expected to extend the range of semiconductor devices further. The probability is that as these become commercially significant they also will do so as a result of the exploitation, in numerous variations, of the two basic metallurgical phenomena of alloy segregation and diffusion.

Acknowledgements

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List of Symbols

V_{min}	In an intrinsic region transistor the minimum voltage required for the space charge to widen across the intrinsic region.
k	The segregation coefficient (ratio of impurity concentration in the solid to that in the liquid at the interface).
g	That fraction of the original volume which has solidified.
D	The diffusion coefficient.
α_{fe}	The small signal short-circuit forward current transfer ratio. (common emitter)
α_{rb}	The small signal short-circuit reverse current transfer ratio. (common base)
$r_{b\ extr.}$	Extrinsic base branch resistance.
f_{ab}	The frequency at which the magnitude of α_{fb} is .707 of the low frequency value.
C_C	Collector capacitance.
V_p	The voltage at which the space charge region extends from the collector to the emitter junction.
BV_{CB}	The avalanche breakdown voltage from collector to base, emitter open circuited.
V_{SAT}	Saturation voltage or voltage measured from collector to emitter when the transistor is operating in the saturation region.

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Performance of Transistors As Tuned Power Amplifiers At VHF

BERNARD REICH* and WILLIAM ORLOFF*

Results are presented of an investigation to determine the power capability of transistors designed for power performance in the region of 70-100 *mc*. Two types of germanium units and one type of silicon device were used in the experiments. Basic measurement circuits are illustrated, and tables showing performance characteristics are included. Important device characteristics are given, as well as suggestions for improved efficiency.

THE CAPABILITY of transistors as power amplifiers at very high frequencies has never been fully exploited. This implication is based on the fact that diffused-base transistors with good thermal characteristics have been available for approximately two years without investigation of their performance at reasonable power levels. Recently investigations were initiated at this Laboratory to determine, at least to a first approximation, the power capability of transistors designed for power performance in the region of 70-100 *mc*. It is realized in preparing this article that all of the questions arising as a result of these investigations have not been answered, but it is the purpose of the authors to report their findings and to stimulate further device and circuit work. It is believed that by further device refinement and circuit design, the capability of the transistor as a power device capable of delivering one to two watts at frequencies of 70-100 *mc* is realizable in the near future.

Experimental Procedure

Three different types of devices were available to the authors at the time of investigation; two fabricated from germanium, the other from silicon. The germanium devices had frequency characteristics yielding a gain bandwidth product ($h_{fe} \times$ measured frequency) of approximately 500 *mc*. The silicon transistor had a maximum frequency of oscillation in the range of 200 *mc*. All units have the collectors directly connected to the can and (as best as could be determined by direct measurements made at this Laboratory and information supplied by the manufacturer) the germanium units had thermal resistance values between junction and case of 50 and 110-°C/watt respectively. Information on the silicon transistor was not readily available. Solid aluminum and copper heat dissipators which had surface areas of approximately seven square inches were used during the course of the measurements. The class of operation in both germanium devices is Class C. Because of device characteristics not yet fully understood, the silicon transistor appeared to operate most efficiently in Class AB.

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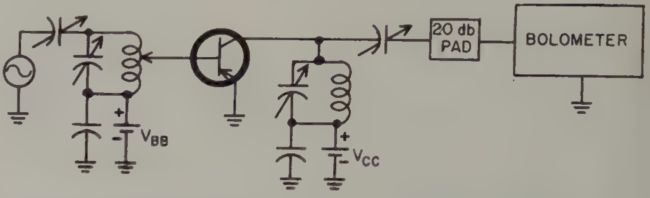

Fig. 1—Measurement circuit for germanium devices.

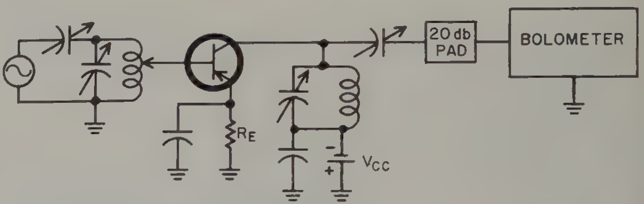

Fig. 2—Measurement circuit for silicon device.

The two basic circuits used for measuring the performance of the devices are shown in *Fig. 1* and *2*.

In *Fig. 1*, a resistor R_E is used in the emitter to provide emitter back biasing during operation. For the two germanium devices measured, it was found that 10 and 27 ohms seemed optimum for the devices examined. For the silicon transistor, a forward bias was used to optimize the operating conditions best suited for this device. In the case of the germanium devices, the back bias appearing across the emitter to base is $I_E R_E$ plus the characteristics of the device contributing to the back biasing effect. Typical operating conditions indicated an average current up to 50 milliamperes yielding back biases up to 0.5 volts and 1.3 volts during operation.

Results

For the purposes of clarification in future results reported, the following definitions are adopted on various parameters:

TABLE I
Performance of Germanium and Silicon Devices

Device Designation	Unit #	Freq (mc/sec)	P Output (Watts)	P Gain (db)	Collector Efficiency (%)
Ge 1	56	75	.44	5.6	45
		106	.40	7.6	43
	313	75	.54	5.5	42.5
		106	.61	6.1	44
Ge 2	200	70	.54	7.8	74
	201	70	.41	6.7	65
Si		70	1.0	7.0	52

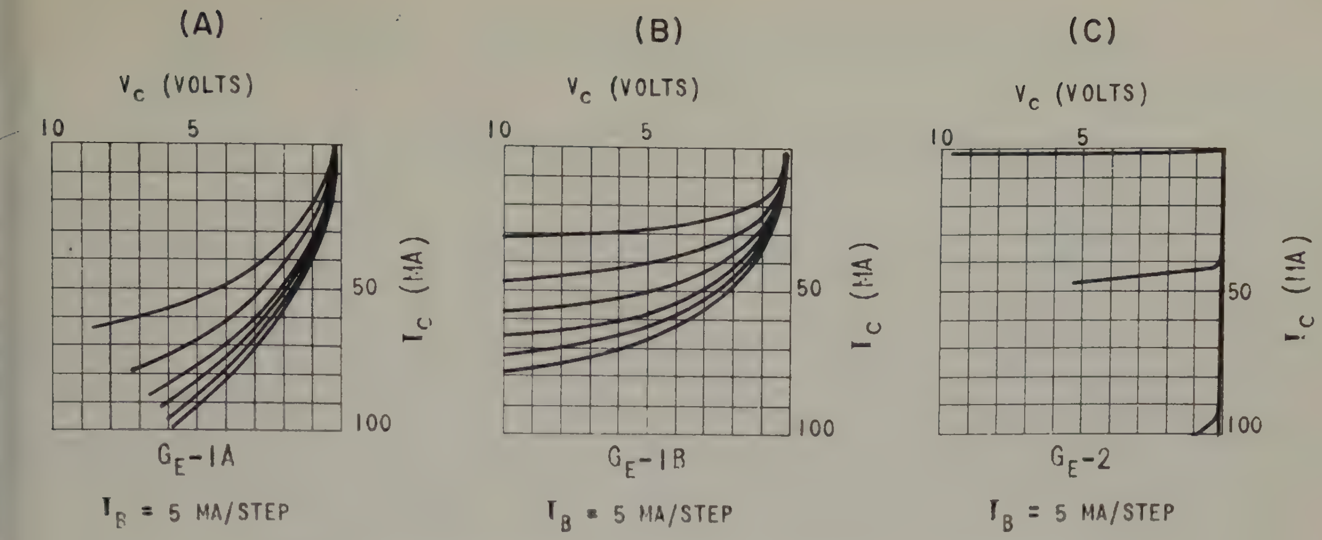

Fig. 3—Saturation characteristics. (Germanium devices)

$$\text{Collector Efficiency} = \frac{P_o}{V_c I_c}$$

where P_o = *a-c* power output,
V_c = *d-c* collector voltage across the transistor,
I_c = the average collector current.

$$\text{Power Gain} = \frac{P_o}{P_{in}}$$

where P_{in} = *a-c* power input.

Table I is a tabulation of results on various device types examined. For the purpose of clarity, the germanium units are represented as Ge 1 and Ge 2 respectively, and the silicon device as Si.

Table I indicates that silicon and germanium devices exist which are capable of delivering .4 to 1.0 watts in the frequency range 70-100 *mc/sec* with gains of approximately 5-8 *db* with varying efficiencies of 42-74%. The results given in Table I are on devices which are experimental (Ge 2 and Si), while the Ge 1 device is in partial production.

Analysis of Results

With respect to the germanium devices operated as Class C amplifiers, some analysis of the device performance will be presented. In the following discussion, it is assumed that the driving and output voltages are sinusoidal although oscillographic data is not available. The back bias across the base to ground at the input of the transistor is:

$$V'_{BE} = I_{c\,av} R_E + V_{BE} \qquad (1)$$

where $I_{c\,av} R_E$ is the voltage drop across the emitter resistor and

V_{BE} is the forward voltage across base to emitter necessary for forward conduction.

[1] Fundamentals of Vacuum Tubes—Eastman; McGraw-Hill Publishing Company.

In the Ge 1 transistor, V_{BE} was found to be 0.2 volts while for the Ge 2 unit it was 0.18 volts. In a typical operational setup, *a-c* and *d-c* levels of power voltage and current were noted as listed in Table II

TABLE II
Typical Conditions in Tuned Power Amplifier Circuit

Device Designation	Freq mc/sec	V_{CC} Volts	$I_{c\,av}$ ma	P_o Watts	P_{in} Watt	v_{in} rms volts	v_{out} rms volts	V'_{BE} Volts
Ge 1	75	26	44	.520	.110	2.5	12.5	1.15
Ge 2	70	17	42	.510	.072	1.65	10.7	0.54

From Table II, the peak value of voltage swing at the collectors may be calculated. For the GE 1 device, this would be approximately 17.7 volts, and for the Ge 2 device, 15.2 volts. It must, therefore, be assumed that the voltage swing is limited by the *d-c* characteristics of the Ge 1 device in the case cited in Table II, this bottoming voltage being approximately 8.3 volts. In the Ge 2 device, approximately the maximum voltage swing occurs, and only 1.8 volts is not accounted for in the measurements.

The degree of current flow in the collector circuit is now calculated on the basis of the data presented

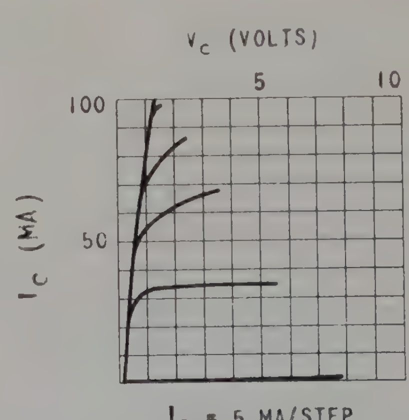

Fig. 4—Saturation characteristics. (Silicon device)

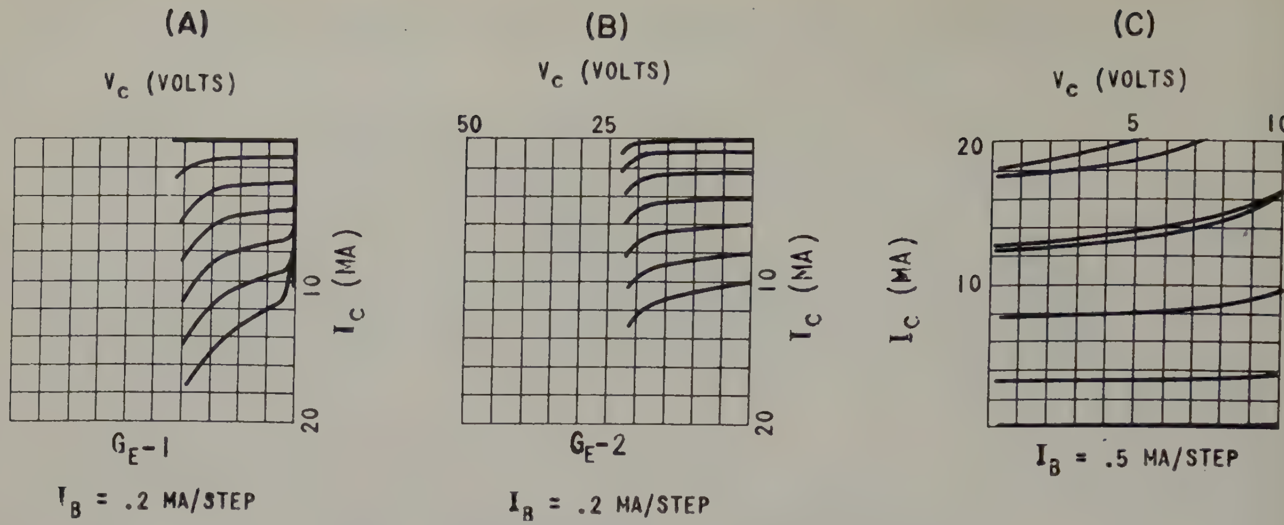

Fig. 5—Collector characteristics. Breakdown voltage.

in Table II and the assumption previously made. Assuming $v_{in} = v_o \sin \theta$, the angle of current flow for the Ge 1 device is 142°, and for the Ge 2 device 153° indicating a shallow Class C operation. If the angle of current flow is known, the peak value of collector current may be determined with the assistance of curves based on Fourier Series analysis[1]. This yields maximum collector currents of 76 and 71 milliamperes respectively for Ge 1 and Ge 2. Calculating the output power on the basis of the information yields calculated power outputs of .670 and .530 watts for Ge 1 and Ge 2. The calculation for the Ge 2 device is quite accurate; however, some difference in calculated reading and observed result is noted. It is believed that this results from device characteristics, particularly the saturation voltage, and will be discussed in a following portion of the report.

Other characteristics such as the load impedance and average value of current gain at the operating frequency have also been calculated. These results along with others previously given are summarized in Table III.

TABLE III
Summary of Class C Performance Characteristics

Device Designation	θ Current Flow in degrees	Z_L (Ohms)	I_{cp} (ma.)	V_{Cp} (Volts)	h_{fe} Operating Freq.
Ge 1	142	305	76	17.7	0.95
Ge 2	153	224	71	15.2	1.1

An interesting conculsion may be drawn on the basis of Table III; that the power gain is mainly a function of the voltage gain of the device examined.

Important Device Characteristics

From this investigation it has been found that the performance of these devices depends mainly on two important conditions:

a. The device must have frequency characteristics commensurate with the operating frequency. This statement, it is realized, is general; however, the device will or will not perform and the power gain characteristic especially will suffer.

b. The *d-c* "On" and "Off" characteristics seem to be of vital importance at present.

At this point, some elucidation of statement "b" above is in order. *Fig. 3* indicates the "bottoming" or "on" characteristics of two Ge 1 devices. It is to be noted that *Fig. 3a* is representative of one of the better devices of the Ge 1 class. At approximately 80 milliamperes the saturation voltage is approximately four to five volts depending on the base current drive. In *Fig. 3b*, the saturation voltage is approximately 10 volts at 80 milliamperes. Considering the previous information in the performance of the Ge 1 device, it was noted that the voltage swing in the collector was not at a maximum.

Figure 3c is the saturation characteristic of the Ge 2 device. At a collector current of 70 milliamperes, a fraction of a volt in saturation is noted. This again agrees with the performance data deduced from Table II.

The silicon transistor saturation characteristic is shown in *Fig. 4*. Approximately one volt at 100 milliamperes of current is noted. *Fig. 5* shows the collector characteristics of the three devices examined. Noted in the Ge 1 device is a deterioration in the output characteristic above 10 milliamperes. The high voltage characteristic of the silicon transistors is evident.

It is felt that these output characteristics indicate, especially in the case of the germanium devices, that higher power outputs resulting from improved efficiency are attainable by improvement of the *d-c* characteristics.

This study has indicated that both silicon and germanium devices exist which are capable of power operation at very high frequencies, especially in the 70-100 *mc/sec* range. Although the study was limited to this frequency range, there are indications (especially in the case of the Ge 1 device) that power operation above these frequencies is attainable.

A New Technique For Measuring Transistor Switching Times

RONALD R. JOHNSON,* ROBERT D. LOHMAN,* RICHARD R. PAINTER*

A new test method for improving and simplifying the measurement of transistor switching times is presented. The measurement of transistor switching times is described, and the problems in the presently used method of making these measurements are explained. The new method and its advantages are then presented and explained, and the circuits used in the new test set are described. This article shows how the new method (1) requires little or no adjustment of the oscilloscope controls; (2) is not affected by drift in the oscilloscope amplifiers; (3) allows simultaneous measurements of delay time plus rise time, and storage time plus fall time (again without adjustment of oscilloscope controls); and (4) provides direct, easy recognition of unsatisfactory units by superimposing a reference waveform over the output waveform.

THE MEASUREMENT of switching times is one of the most important measurements made on switching transistors. Unfortunately, it is also one of the most difficult tests to perform. The difficulty is due to the fact that it is necessary to read very short time intervals on an oscilloscope and simultaneously compare the output waveform with the input waveform.

The difficulty of this operation is increased by the fact that slight changes in the oscilloscope amplifier can cause either one or both of the waveforms to drift. Thus accuracy is limited, correlation is difficult, and the test rate is slow.

Transistor Switching Times

Before the method of testing switching transistors is considered, it may be helpful to discuss the method of measuring switching times. The discussion that follows refers to a *p-n-p* transistor only. If the polarities are reversed, the discussion is valid for *n-p-n* transistors. The transistor in the circuit in *Fig. 1a* is normally *off* because the base is held positive with respect to the emitter. When a sufficiently large negative current pulse is applied to the base, the base becomes negative with respect to both the emitter and collector and the transistor is driven into the current-saturation region. Current saturation is characterized by a very high minority carrier density in the base region because both the emitter and collector junctions are forward biased. *Fig. 1b* shows the waveform of the transistor base current. I_{B1} is the turn-on drive current and I_{B2} is the turn-off drive current. *Fig. 1d* shows the waveform of the collector-to-ground voltage that results when the negative voltage pulse shown in *Fig. 1c* is applied to the base of the transistor. The transistor does not turn on immediately at the time of step function No. 1 of the input pulse. This finite time before the transistor starts to turn on is called delay time, and is defined as the period of time between the step function No. 1 of the input pulse and the time at which the collector-to-ground waveform reaches 10 percent of its saturation value. Rise time is defined as the time between 10 percent and 90 percent of the rise of the collector-to-ground waveform from zero to its saturation value.

Figure 1 also shows that the transistor does not turn *off* immediately at the time of step function No. 2. The finite time before the transistor starts to turn off is called storage time and is defined as the period of time between step function No. 2 and time at which

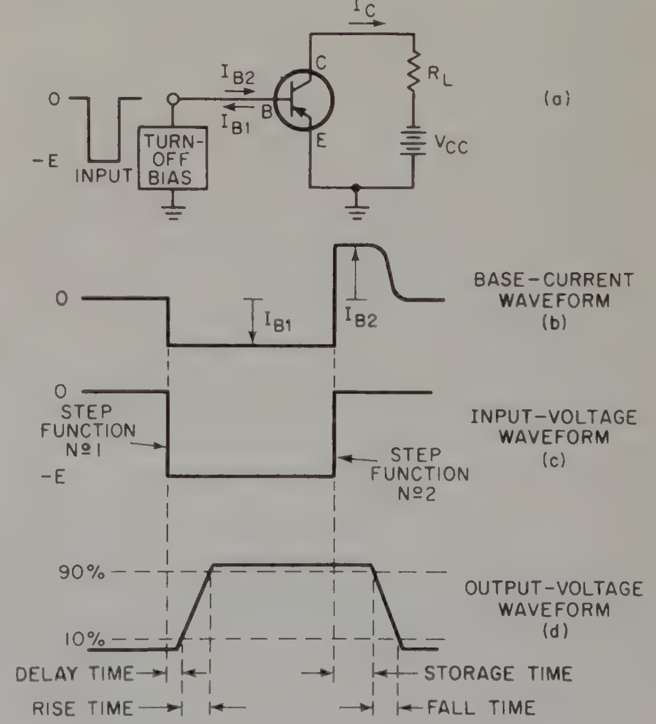

Fig. 1—Switching transistor showing base current waveform, input-voltage waveform, and collector-to-ground (output) voltage waveform.

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the collector-to-ground waveform reaches 90 percent of its saturation value. Fall time is defined as the time between 90 percent and 10 percent of the fall of the collector-to-ground waveform from saturation to its normally *off* value.

The measurement of the delay time and rise time sometimes are lumped together into one measurement for convenience. This measurement is approximately equal to the rise time because the delay time is usually very small. Sometimes, storage time and fall time also are lumped into one measurement, but neither storage time nor fall time is negligibly small for most transistor switching circuits.

Conventional Method For Measuring Switching Times

Figure 2a shows a typical transistor switching circuit. The transistor is normally *off* due to the positive bias, V_2, on the base. The waveform of the input pulse, which is negative and of sufficient amplitude to turn the transistor *on* and into current saturation is shown in *Fig. 2b*, and the collector-to-ground output waveform is shown in *Fig. 2c*. In the conventional method of measuring switching times, these waveforms must be compared on a dual-input scope such as the Tektronix 535 used with preamplifier 53C.

The tester views both waveforms on the oscilloscope screen simultaneously. The height of the output waveform must be adjusted to coincide with the 10 lines on the scope screen as shown in *Fig. 2c*. Step function No. 1 must be lined up with a vertical line on the scope screen when delay time (t_d) and rise time (t_r) are measured, and then the scope must be readjusted so that step function No. 2 is lined up with another vertical line on the screen when storage time (t_s) and fall time (t_f) are measured.

Because the waveforms tend to drift up or down, the position of the waveform must be checked periodically. Drift is particularly objectionable in waveform *(c)* because the lines on the screen are stationary and the tester must determine the switching times of the transistor from the relative position of waveform *(c)* with respect to these lines. All of these manipulations require care, decrease the accuracy of the measurement and greatly decrease the testing speed. Moreover, the factory tester is usually not trained in the use of oscilloscope controls.

New Method For Measuring Switching Times

If the input pulse is applied to a time delay circuit, as shown in *Fig. 3a*, it is possible to obtain a reference waveforms such as shown by the dashed lines in *Fig. 3c*. Then, times t_1 and t_2 are independently adjustable and may be calibrated and set at the desired limits prior to testing. Once t_1 and t_2 have been calibrated, the input pulse waveform, *Fig. 3b*, is to be displayed on the oscilloscope, and the tester only has to observe the waveforms in *Fig. 3c*. (The dashed lines appear as solid lines on the scope). The reference time-delay waveform coincides with the 10 percent line at the bottom level and the 90 percent line at the top level. This alignment is accomplished automatically in the time-delay circuit which will be discussed later.

When an oscilloscope display such as that shown in *Fig. 3c* is used, it is very easy to determine a passing or failing unit. To determine $t_d + t_r$ failures, the tester simply looks at the left top edge (point *A*) of the calibrated time-delay waveform and observes its relationship to the waveform of the transistor under test. If point *A* is to the right, the unit passes the t_1

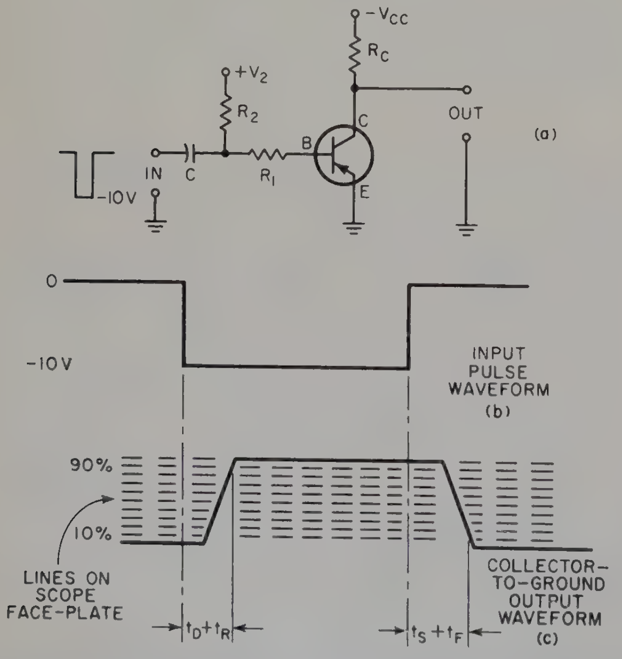

Fig. 2—Typical switching circuit showing comparison of input and output waveform on oscilloscope screen.

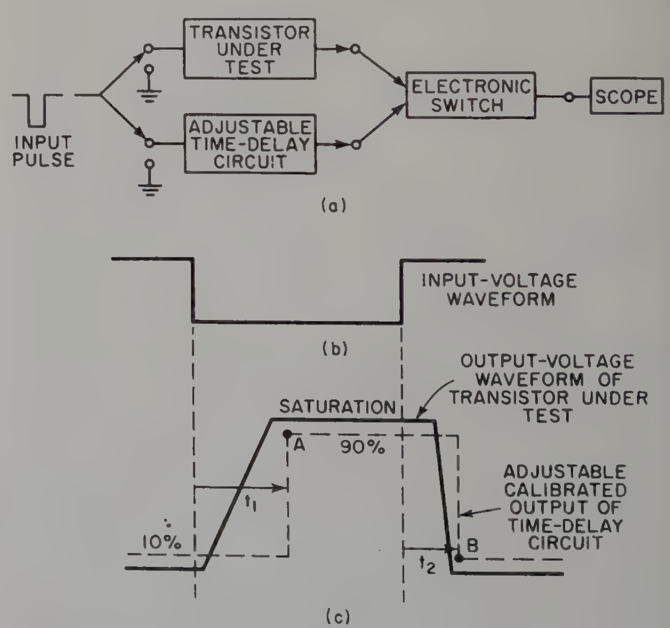

Fig. 3—Block diagram of new Test Set showing input and output waveforms from electronic switch.

limit. If it is to the left, the unit fails. If it falls directly on the line, then the unit has a $t_d + t_f$ equal to the limit.

To determine $t_s + t_f$ failures, the tester looks at point *B* and observes its relationship to the transistor under test waveform. If point *B* is to the right, the unit passes the t_2 limit. If it is to the left, the unit fails. If it falls directly on the line then the unit has a $t_s + t_f$ equal to the limit.

Because both waveforms in *Fig. 3c* go through the same oscilloscope amplifier, there is no drift problem. Moreover, there is no problem of height adjustment and no need to use the reference lines on the scope screen because the 10 percent and 90 percent lines are automatically fixed.

Detailed Description of Circuits Used in New Test Set

Figure 4 is a schematic diagram of the time-delay circuit. In this circuit, the time delay is obtained by utilization of transistor storage time. Pulse delay time t_2 in *Fig. 4* is obtained by adjusting variable resistor R_1, so that transistor T_1 is heavily saturated and has a longer storage time. The increased storage time of T_1, in turn, increases the pulse delay time t_2. In the same way, time t_I can be varied by adjusting the variable resistor R_2 to increase the storage time of transistor T_2. In this circuit t_2 may be varied from 0.7 µsec to 5.0 µsec. and t_1 may be varied from .44 µsec. to 3.30 µsec.

The purpose of the transistor T_3 circuit is to reduce rise and fall times and to sharpen the waveform before it is sent to the electronic switch.

The voltage dividing resistors R_3, R_4, and R_5 automatically keep the amplitude of the output of the time delay circuit between 10 percent and 90 percent of the amplitude of the transistor under test, assuming that the -10 volts utilized in the time delay circuit is also used as the collector voltage, V_{CC}, of the transistor under test.

The purpose of the electronic switch is to apply both outputs to one oscilloscope input and thereby permit simultaneous viewing of the two waveforms on the screen, as shown in *Fig. 3c*. A microswitch may be used for this purpose but it is slower and the resultant waveforms are much more difficult to read.

Figure 5 is the schematic diagram of the electronic switch that is used in the test set described in this article. In this circuit, when transistor T_4 is *on*, input No. 1 is connected directly to the 100,000 ohm resistor R_L. If at the same time T_9 is *off*, input No. 2 is blocked from R_L. Then if T_9 is turned *on* and T_4 turned *off*, input No. 2 is connected directly to R_L and input No. 1 is blocked. Thus, input No. 1 waveforms and input No. 2 waveforms will be alternately seen across R_L. If the positive gate of the oscilloscope is used as the synchronizer, the oscilloscope will read input No. 1 during one sweep-time duration and input No. 2 during the next sweep-time duration. This switching is done so quickly that the two pictures appear as one due to the

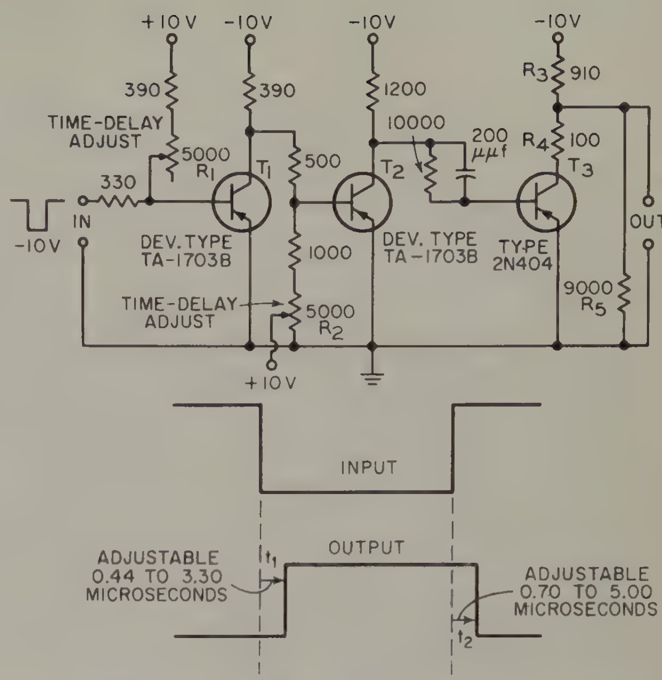

Fig. 4—Schematic diagram of adjustable time-delay circuit.

persistance of the oscilloscope screen.

Transistors T_6 and T_7 are used in a flip-flop arrangement. The trailing edge of the positive gate from the oscilloscope supplies the negative trigger. For example, when T_6 is *on* and T_7 is *off*, the voltage at the collector of T_6 is approximately $+ 0.2$ volts. The base of T_5 is connected to the collector of T_6, and thus T_5 is biased with an emitter current of approximately 3 milliamperes. This current is sufficient to cause T_5 to saturate. The collector of T_5 thus assumes a potential of approximately $+ 0.5$ volts. The base of T_4 is therefore reverse biased with respect to the emitter and the negative input signal on the collector of T_4 is blocked. This arrangement is suitable only if the signals to be gated are always negative with respect to ground. (A simple rearrangement of *d-c* levels permits gating positive as well as negative signals.)

During this time, T_7 is *off*. Therefore, its collector is at approximately $+10$ volts. The emitter of T_8 is $+ 2.3$ volts and therefore, T_8 is *off*. T_9 is thus supplied with sufficient base current to saturate and pass the input signal at its collector to emitter terminal.

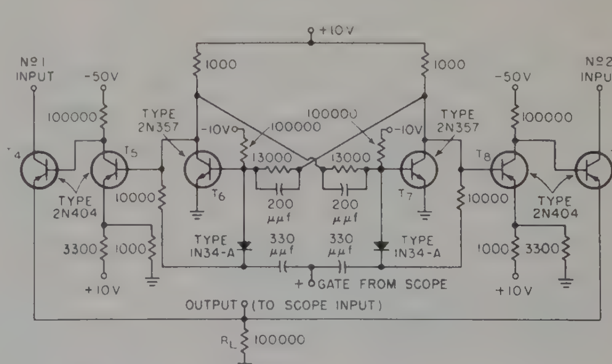

Fig. 5—Electronic switch used in Test Set.

APPLICATIONS ENGINEERING DIGESTS

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APPLICATIONS ENGINEERING DIGEST No. 1

No. 1—***Ultra High Speed Switching Circuits Using the Microalloy Diffused-Base Transistor (MADT).*** Landsdale Tube Co. Division of the Philco Corp.

A number of high speed experimental switching circuits are described, utilizing direct-coupled transistor logic, resistor-coupled transistor logic and resistor - capacitor - coupled transistor logic. Among the circuits described are a 1 *mc* ring counter using capacitor memory storage for gating purposes, a 45 *mc* resistor-capacitor-coupled transistor binary counter, a 1 *mc* resistor-coupled transistor logic circuit, and a 10 *mc* blocking oscillator. Performance data and temperature stability of various circuits are discussed.

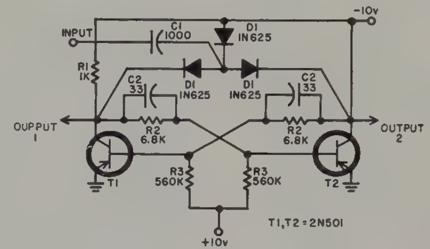

Fig. 2—MADT binary counter with diode trigger steering.

Direct Coupled Transistor Logic (DCTL)

Direct coupled transistor logic offers simplicity and full utilization of transistor characteristics. The main requirement of direct-coupled transistor logic is that the saturation voltage of the transistor be less than the required base voltage to cause the following stage to conduct. *Fig. 1* illustrates a two-stage switch that is direct coupled.

Resistor-Capacitor-Coupled Transistor Logic (RCTL)

Resistor-capacitor-coupled transistor logic, which lends itself to diode gating is a carryover from vacuum tube circuitry. *Fig. 2* illustrates a resistor-capacitor-coupled binary counter that utilizes diode transistor gating.

Resistance-Coupled Transistor Logic (RTL)

Resistor-coupled transistor logic (RTL) is an attractive circuit connection from an economical point of view. It offers a considerable saving of transistors over direct-coupled transistor logic but there are some drawbacks such as increased switching time and decreased logical gain. However, with the MADT, RTL repetition rates above 1 *mc* have been obtained without selection of transistors. The basic RTL circuit is illustrated in *Fig. 3*.

Special Pulse Circuits—Blocking Oscillators

Fig. 4 illustrates a 10 *mc* free running blocking oscillator which has an output pulse width of 28 millimicroseconds.

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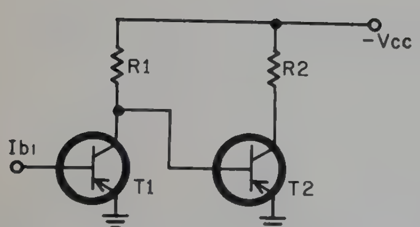

Fig. 1—Two stage direct coupled switch.

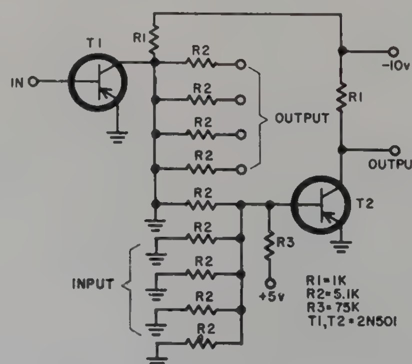

Fig. 3—Basic RTL circuit.

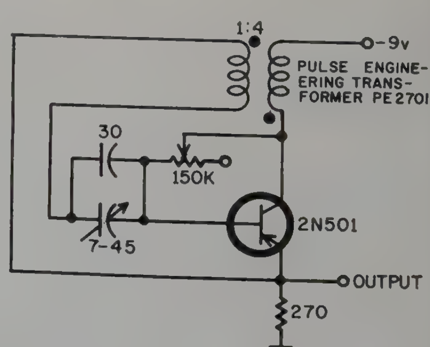

Fig. 4—10 *mc* blocking oscillator.

APPLICATIONS ENGINEERING DIGEST No. 2

No. 2—***60-mc I-F Amplifier Using Silicon Tetrodes.*** Texas Instruments Inc.

Compact, high-performance, intermediate-frequency amplifiers are widely used in radar and missile applications. The advantages in size and weight reduction to be gained by transistorization of these circuits are many. However, until recently, the attractiveness of this approach has been limited by low gain, poor interchangeability, and lack of environmental ruggedness.

Recent developments in silicon transistors have provided devices which overcome these objections and thus make practical the design of high-gain, wide-band i-f amplifiers. This report describes one such design which is representative of the capabilities of these devices.

Eight-Stage Amplifier

Figure 1 is a schematic of the entire amplifier. The input and output transformers depend on source impedance and load impedance, respectively. Table I indicates the results obtained.

Table I

Gain	105 db
Bandwidth	20 mc
Center Frequency	60 mc
Gain Variation to 85°C	—8 db (See following discussion on temperature performance)

No neutralization. Absence of regeneration. Design suitable for production.

The final amplifier, when tested, exhibited a lack of any type of regeneration. The test results closely followed the performance expected from preliminary calculations. This lack of regeneration is due partly to the low impedance levels present in the circuit but primarily to impedance mismatch between stages. The ordinary considerations in the layout and packaging of high-frequency circuits apply to this design. The final form of the amplifier used a cover plate, but no evidence of instability could be detected without it.

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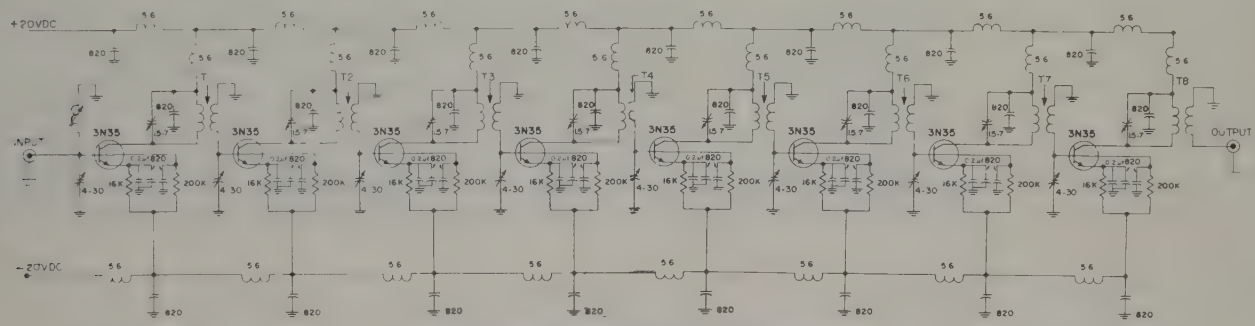

Fig. 1—Schematic of 60 *m* *i-f* amplifier.

APPLICATIONS ENGINEERING DIGEST No. 3

No. 3—***Broadcast Band Frequency Converter Using R.C.A. Transistors 2N140, 2N219, 2N411, or 2N412.*** Radio Corporation of America, Sommerville, N.J.

This note describes a broadcast band frequency converter. The circuit has an average gain of 30 *db* when operated from a 9-volt battery, and operates dependably at reduced battery voltage. Within the operating conditions of the circuit described, the performance of all four transistor types is the same.

Circuit Description

The basic circuit of the converter is shown in *Fig. 1*. The circuit uses a series-feed oscillator with emitter injection to minimize interaction between the oscillator and antenna sections, and requires a five-terminal oscillator coil. Capacitor C_e is used to couple the signal from the oscillator coil to the emitter, and also as an *r-f* bypass for the emitter-circuit resistor R_e. The considerations which determine the values for the various components, and the design of the oscillator coil and antenna section are discussed in the basic note.

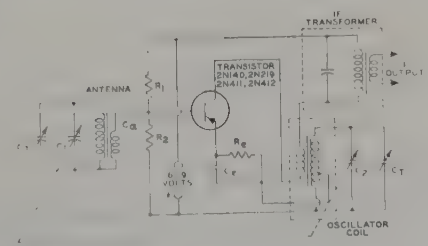

Fig. 1—Basic converter circuit.

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ELECTROLYTIC SLICING— This engineer is slicing a germanium crystal by electrolytic means. Up to now semiconductor wafers have been formed by mechanical processes, such as cutting with diamond saws or lapping with abrasive powders. The resulting mechanical damage to the critical surfaces reduces the quality and effectiveness of finished semiconductor devices. Electrolytic slicing of crystals, producing surfaces which are free from the mechanical damage resulting from other methods, is one of the many pioneering activities initiated and carried forward by the scientists and engineers of Raytheon's Semiconductor Division.

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Quarterly Progress Report (44th, January 1957)	U.S. Gov't Research Reports PB 133418-LC 10/17/58	Reviews work during the period on the subjects treated in the previous report; also on other subjects including solid state physics.	J. B. Wiesner G. G. Harvey H. J. Zimmerman
Quarterly Progress Report (43rd, Oct. 1956)	U.S. Gov't Research Reports PB 133419-LC 10/17/58	Reviews work during the period covered on various electronics fields including transistor circuits.	J. B. Wiesner G. G. Harvey H. J. Zimmerman

Title	Publication	Condensed summary	Author
Operation and Specification of Transistors for Direct-Coupled Logic Circuits	U.S. Gov't Research Reports PB 133052-LC 10/17/58	Many designers have turned to direct-coupled transistor circuits where simplicity, low component count and ruggedness prevail.	D. P. Masler
Maximum Operating Junction Temperature and Reliability	U.S. Gov't Research Reports PB 133053-LC 10/17/58	Measurements were made of the variations of characteristics with temperature of germanium and silicon transistors.	J. Mandelhorn
Industrial Preparedness Study on Surface-Barrier Transistors	U.S. Gov't Research Reports PB 128016-LC 10/17/58	1—Specifications; 2—Electrical properties; 3—Tests; 4—Design.	J. D. McCotter C. G. Thornton
Industrial Preparedness Study on Transistors	U.S. Gov't Research Reports PB 127679-LC 10/17/58	Silicon Transistors: 1—Fabrication; 2—Manufacturing equipment; 3—Design.	F. M. Dukat G. Freedman
Temperature Stabilization of Transistor Amplifiers	U.S. Gov't Research Reports PB 127095-LC 11/14/58	Method of analysis of the thermal behavior of transistor amplifiers by introducing temperature incremental equations. Design formulas are derived.	L. M. Vallese
Industrial Preparedness Study, Diffused Semiconductor Devices—Device 7	U.S. Gov't Research Report PB 133393-LC 11/14/58	Device 7 objective specifications call for a 70 Mcps i-f amplifier gain greater than 15 db at $I_e = 1$ *ma*, $V_c = -5.0$ volts.	J. M. Early C. H. Knowles
Transistorized Coordinate Data Set	U.S. Gov't Research Reports PB 133598-LC 11/14/58	The overall data transmission system philosophy is discussed and the theoretical and practical aspects of the transistorized design are presented.	F. Hoffman D. Randice J. Stingelin
Industrial Preparedness Study, Transistor Manufacturing	U.S. Gov't Research Reports PB 133333-LC 11/14/58	1—Transistors, Silicon-Design. 2—Transistors, Silicon-Fabrication. 3—Transistors, Silicon-Specifications.	C. Orman
Industrial Preparedness Study on Surface-Alloy Silicon Transistors	U.S. Gov't Research Reports PB 132504-LC 11/14/58	1. Transistors, Silicon-Fabrication. 2. Transistors, Silicon-Design.	J. Roschen C. G. Thornton
Fundamentals of Junction Transistor Physics	U.S. Gov't Research Reports PB 127055-LC 11/14/58	[no summary]	W. J. Poppelbaum
Industrial Preparedness Study on Device 1	U.S. Gov't Research Reports PB 133334-LC 11/14/58	Improvement on both *n-p-n* and *p-n-p* versions of germanium Device #1 is discussed.	A. E. Mohr
Upper Limits of Output Power in Vacuum Tube and Transistor A-C Amplifiers	U.S. Gov't Research Reports PB 132208-LC 11/14/58	Procedure of design for maximum power output is given taking into account the current, voltage and power limitations of the unit.	L. M. Vallese
Transistor Regulators for 5-Ampere Currents	U.S. Gov't Research Reports PB 134324-LC 11/14/58	1. Transistors—Circuits—Design—Canada 2. Voltage Regulators—Design—Canada 3. Order from Nat'l Research Council of Canada, Ottawa, Canada (25¢).	J. K. Puefer D. W. R. McKinley
Transistor Magnetic Amplifier Circuits	U.S. Gov't Research Reports PB 132806-LC 11/14/58	Discussion of advantages and disadvantages of transistor and magnetic amplifiers. A combination of the two is discussed and analyzed.	N. Jasper J. C. Taylor W. T. White
Industrial Preparedness Study on Diffused Semiconductor Devices	U.S. Gov't Research Reports PB 133335-LC 11/14/58	A feasibility study with regard to 4. 3 *mc* silicon amplifier device indicates requirements of large scale production could be met. Flow chart illustrates fabrication in block diagram form.	R. Williams
Basic and Applied Research on Semiconductors	U.S. Gov't Research Reports PB 134716-LC 11/14/58	In Section A investigations of electric and magnetic properties of IIa group titanates are reported. In Section B investigations of the characteristics and equivalent circuits of thermistors are discussed.	E. K. Weise
Research on Solid State Diffusion in Semiconductor Materials	U.S. Gov't Research Reports PB 132300-LC 11/14/58	Silicon surface preparation and properties have been investigated in their relation to diffusion.	T. J. La Chapele
Research and Development "Alpha-Greater-Than-One" Silicon Devices	U.S. Gov't Research Reports PB 132350-LC 11/14/58	Summarizes work done to develop a reproducible negative-resistance silicon two-terminal device.	
Investigation of Techniques for Production of High Ambient Silicon-Germanium Point Contact Switching Transistors	U.S. Gov't Research Reports PB 133327-LC 11/14/58	Studies made of crystal growing, material processing, forming techniques and encapsulation problems.	H. M. Meyer D. E. Humez

PATENT REVIEW*

Of Semiconductor Devices, Fabrication Techniques and Processes, and Circuits and Applications Nov. 30, 1954 to Sept. 6, 1955

Compiled by SIDNEY MARSHALL

The abstracts appearing in this issue cover the inventions relevant to semiconductors from Nov. 30, 1954 to Sept. 6, 1955. In subsequent issues, patents issued from Sept. 6, 1955 to date will be presented in a similar manner. After bringing these abstracts up to date, PATENT REVIEW will appear every three months, the treatment given to each item being more detailed.

November 30, 1954
2,695,852 Fabrication of Semiconductors for Signal Translating Devices—M. Sparks. Assignee: Bell Telephone Laboratories. A fabricating method consisting of vapor depositing a material selected from a group consisting of acceptors and donors upon a body of semiconductive silicon or germanium in an inert atmosphere while maintaining the temperature of the body above the melting point of the semiconductor-impurity eutectic.

3,695,930 High Frequency Transistor Circuit—R. L. Wallace. Assignee: Bell Telephone Laboratories. A junction device in which the junction is disposed in a plane normal to the longest dimension of the body of semiconductive material, said body having a recess therein whereby the conductive area of said junction is reduced to a minor fraction of the area of a second zone of the device coplanar with the junction.

2,695,979 Transistor Unit—A. M. Creighton. Assignee: Motorola Inc. A transistor unit including a base block having a rectangular cavity and two metallic plates supported in said cavity, said plates being insulated from one another.

December 7, 1954
2,696,574 Transistor Unit—G. C. Rich. Assignee: Motorola Inc. A device consisting of a flat insulating base, a pair of rigid spaced metallic leads, a semiconductive device having a pair of inclined faces with an edge formed by the line of juncture, and means for supporting the semiconductor.

2,696,575 Transistor Unit—G. W. Fogg. Assignee: Motorola Inc. A unit including a base member, a pair of electrically conductive strips, a third conductive strip, and a block of semiconductive material in contact with the third strip and having an edge in point contact with each of the edges of the first-mentioned strips.

December 14, 1954
2,696,739 Temperature Responsive Semiconductor Circuits—R. O. Endres. Assignee: Radio Corporation of America. A regenerative transistor circuit wherein changes of internal impedance of the semiconductor or changes of currents flowing through the device in response to ambient temperature changes are utilized to provide temperature indication.

* Source Official Gazette of the U. S. Patent Office, and Specifications and Drawings of Patents Issued by the U. S. Patent Office.

2,697,188 Selenium Rectifier—I. Goldman, W. B. Roberts. Assignee: Sylvania Electric Products Inc. A current rectifier comprising a plurality of rectifier units superimposed on the surface of a non-conductive material having a corrugated cross section.

2,697,189 Electrode For Semiconductor Devices—J. P. Stelmak. Assignee: Radio Corporation of America. A pair of filamentary electrodes having one end secured to a supporting member, the other end in sharp point-contact with a semiconductive body, said electrodes having a curved portion that provides a spring action when said supporting member is pressed towards the semiconductor.

2,697,201 Adjustable Non-Linear Resistance—E. L. Harder. Assignee: Westinghouse Electric Corporation. In an adjustable impedance unit a first circuit comprising in series, a rectifier and an adjustable resistor and at least one additional circuit shunting said resistor, said additional circuit comprising in series a rectifier, a source of voltage, and an adjustable resistor.

December 21, 1954
2,697,268 Diode Fabricating Apparatus—R. C. Ingraham. Assignee: Sylvania Electric Products Inc. Apparatus comprising a support, a chuck mounted thereon, means for clamping a fitting carrying a resilient whisker, means for supporting a tube for assembly with said fitting and means for adjusting the whisker prior to assembly of the tube.

2,697,269 Method of Making Semiconductor Translating Device—C. S. Fuller. Assignee: Bell Telephone Laboratories. A method of altering the electrical characteristics of a circuit element by polishing a portion of the surface of the semiconductive body, coating a contact with a layer of significant impurity bearing compound, and causing a current to flow between the contact and the body.

2,697,805 Point-Contact Rectifier—R. B. Collins Jr. Assignee: Sylvania Electric Products Inc. A hermetically sealed cartridge type point-contact device.

2,697,806 Glass Enclosed Electrical Translator—P. E. Gates. Assignee: Sylvania Electric Products Inc. A device comprising a semiconductive crystal, a resilient catwhisker in contact with said crystal, a vitreous envelope having a reentrant portion, and leads fuzed through said envelope at opposite ends thereof and separately supporting said crystal.

January 4, 1955
2,698,918 Dry Disk Rectifier Assembled From Unperforated Rectifier Plates—J. H. Eisele, A. R. Geisseloder. Assignee: International Standard Electric Corporation. An assembly for mounting a stack of plates consisting of an enclosure, an assembly therein for providing aligned grooves into which the rectifier plates are fitted and secured.

January 11, 1955
2,699,521 Filament Bar Casing—S. Weiss. Assignee: None. A Casing for a filament bar of semiconductive material comprising a cup-shaped housing, a holder with a slot, the filament bar in said slot, and leads affixed to said holder.

February 1, 1955
2,701,281 Amplifier Employing Semiconductor—C. de Boismaison-White, K. A. Matthews. Assignee: International Standard Electric Corporation. A semiconductor amplifier comprising among other items, a control electrode in contact with the surface of a semiconductive body, the control electrode being spaced a distance from the collector and emitter, said distance being such that the gain of the amplifying device can be adjusted by varying the current in the control electrode.
2,701,302 Semiconductor Frequency Converter—R. J. Giacoletto. Assignee: Radio Corporation of America. A system comprising a semiconductive body having an elongated portion, two low-resistance contacts therewith, two rectifying contacts therewith having a predetermined spacing from each other, means for applying an electric field between contacts 1 and 2 in order to cause charge carriers injected by contact 3 to travel towards contact 4, a modulated carrier wave source, and a local oscillator voltage source.
2,701,309 Semiconductor Oscillation Generator—H. L. Barney. Assignee: Bell Telephone Laboratories. An oscillation generator comprising a transistor, a parallel-connected resistor-condenser combination series connected between the base and a junction point to promote low-frequency feedback of collector current to the emitter, and a second similar circuit to restrict intermediate frequencies.
2,701,326 Semiconductor Translating Device—W. G. Pfann, H. C. Theuerer. Assignee: Bell Telephone Laboratories. A device comprising a body of germanium having therein a synthetic grain boundary extending between opposite faces of said

body, and an ohmic connection to said body and contacting said boundary.

February 15, 1955
2,702,316 Signal Modulation System—A. W. Friend. Assignee: Radio Corporation of America. In a signal modulation system, a semiconductive body, means for establishing an electric field along a predetermined axis, means for impressing an input signal between the emitter and the base to provide a flow of charge carriers between the emitter and the collector, a second axis normal to the first, means for applying a varying magnetic field perpendicular to the plane of axes 1 and 2 in order to vary an output signal derived between the collector and the base.

2,702,359 Rectifier Assembly and Spacer Member for Use Therein—C. A. Woodward. Assignee: United-Carr Fastener Corporation. A rectifier stack assembly utilizing a spacer between adjacent rectifier plates, said spacer comprising a base with a downwardly embossed portion therein in electrical contact with the rectifying side of an adjacent plate.

2,702,360 Semiconductor Rectifier—L. J. Giacolleto. Assignee: Radio Corporation of America. A device comprising a stacked arrangement of semiconductive bodies having a p-type zone, an n-type zone and a p-n rectifying barrier, said bodies being separated by metal electrodes integrally bonded to the p-zone of each body on one side, and to the n-type portion on the other side.

2,702,361 Semiconductor Rectifier or Amplifier of Any Desired Surface Profile—K. Seiler, L. Fedotowski; Assignee: International Standard Electric Corporation. A device characterized by the presence in the surface thereof of grooves having ends which face each other and are spaced apart at a small distance, and pointed electrodes inserted in the grooves at the ends thereof.

February 22, 1955
2,702,838 Semiconductor Signal Translating Device—J. R. Haynes. Assignee: Bell Telephone Laboratories. A device comprising a body of silicon, means for injecting minority carriers, means for filling traps in said body with said carriers so that a sufficient number of carriers are inserted to afford an output pulse having a duration not significantly exceeding the duration of the input pulse.

March 1, 1955
2,703,368 Pulse Regeneration—L. R. Wrathall. Assignee: Bell Telephone Laboratories. A device designed to regenerate two-valued or binary pulses which have been transmitted by way of a channel which fails to pass currents of zero or low frequencies, i.e., by way of an a-c channel.

2,703,388 Magnetic Cross Valve Circuits—H. J. McCreary. Assignee: Automatic Electric Laboratories. In a magnetic system, a saturable magnetic core structure, a source of varying direct current, a control winding, a bridge rectifier, an a-c source, an anode winding, and an output circuit for providing amplification of an input signal in response to the variation of the reactance of said anode winding.

March 8, 1955
2,703,855 Unsymmetrical Conductor Arrangement—W. Koch, H. U. Harten. Assignee: Licentia Patent—Verwaltungs—G.m.b.H. (Germany). A semiconductor device arranged in such a way so that heat formed at the blocking layer of the semiconductive body is conducted away from the body at a rate of heat conduction greater than that in any other part of the body.

2,703,856 Germanium Diode—S. J. Powers, W. F. Bonner. Assignee: International Telephone and Telegraph Company. A crystal contact device comprising a housing in which are supported a semiconductive body, and an elongated conductive contact member making contact with said body over a limited area.

March 15, 1955
2,704,332 Modified Bridge Rectifier Circuit—R. S. LaFleur. Assignee: Hughes Aircraft Company. A rectifying circuit for providing two unidirectional output potentials of different magnitudes.

2,704,340 Semiconductor Devices and their Manufacture—D. R. Baird. Assignee: Radio Corporation of America. A device comprising a semiconductive body, at least two small area contact electrodes, an insulating spacer between said electrodes, support rods, a support plate having a plurality of openings adapted to receive said electrodes, spacer and support rods.

March 22, 1955
2,704,792 Amplifier With Adjustable Peak Frequency Response—E. Eberhard, R. O. Endres. Assignee: Radio Corporation of America. A system having a device with a variable capacitive characteristic, an inductor connected between the base electrode and a junction point; the capacitance of said device and the inductance of said inductor affording a circuit resonant at a predetermined signal frequency tunable by adjustment of a bias current.

2,704,818 Asymmetrically Conductive Device—H. Q. North, Assignee: General Electric Company. A germanium diode for microwave use comprising a pellet of germanium containing about .2 atomic percent antimony, and a pointed wire whisker welded at the pointed end to the surface of said pellet.

March 29, 1955
2,705,287 Pulse Controlled Oscillator Systems—A. W. Lo. Assignee: Radio Corporation of America. A controllable oscillator circuit comprising a current multiplication transistor, a resonant tank circuit, a rectifying device connected in parallel and poled oppositely to the base-emitter path, means for rendering the circuit alternately operative and inoperative, and signal output means coupled to the collector electrode.

April 5, 1955
2,705,767 P-N Junction Transistor—R. N. Hall. Assignee: General Electric Company. A power transistor having major dimensions much greater than its thickness dimension, and having along its thickness dimension an n-p-n type construction.

2,705,768 Semiconductor Signal Translating Devices and Methods of Fabrication—J. J. Kleimack, R. L. Trent Assignee: Bell Telephone Laboratories. A fabricating method which comprises bonding a metallic member to a semiconductive matrix, extracting from the matrix a semiconductive body which adheres to the metallic member, and applying a contact to said extracted body.

April 12, 1955
2,706,222 Transistor Lockout Circuit—B. J. Bjornson. Assignee: Bell Telephone Laboratories. A lockout system comprising at least one transistor with a negative resistance range and positive resistance components; and means for causing the time for the transient rise of current through said negative range to be greater than the severance time of a parallel selectable circuit.

April 26, 1955
2,707,251 Dry Contact Rectifier—W. S. Master. Assignee: International Telephone And Telegraph Company. A stacked rectifier arrangement having rectifier plates with metal-jacketed hermetically-sealed asymmetrically conductive interfaces between the base member and the counter-electrode.

May 3, 1955
2,707,319 Semi-Conducting Device—M. Conrad. Assignee: Stromberg Carlson Company. A production method which comprises embedding a longitudinal conductor in a mass of insulating material to form an assembly; cleaving said assembly in two portions; selectively etching the cleaved surface of each portion so as to leave a conductor with a projecting end; depositing a semiconductive film thereon; depositing a second film over the first; and mechanically reassembling the finished device.

2,707,752 Transistor Multivibrator—R. T. Gabler. Assignee: North American Aviation Inc. A device designed to provide a multivibrator adapted to be bistable or monostable by simple substitution of circuit component values, and a free running multivibrator.

2,707,762 Transconductor Employing Line Type Field Controlled Semiconductor—O. M. Stuetzer. Assignee: None. A transconductive device comprising a semiconductor, an output electrode structure having a plurality of parallel disposed contact elements making line contact with said semiconductor, a control electrode structure, means for electrically interconnecting said contacting elements, and then connecting them to an external circuit.

May 10, 1955
2,708,255 Minute Metallic Bodies—S. Y. White. Assignee: Private assignments. The device comprises a spherical germanium body not more than 2 mm. in diameter in a metallic holder, said body having physical and electrical properties characteristic of a body having been reduced from germanium dioxide.

May 17, 1955
2,708,646 Method of Making Germanium Alloy Semiconductors—H. Q. North. Assignee: Hughes Aircraft Company. A method involving the addition of an acceptor impurity to a specimen of n-type germanium.

2,708,720 Transistor Trigger Circuit—A. E. Anderson. Assignee: Bell Telephone Laboratories. A circuit comprising a current-multiplication transistor and a network providing regenerative current feedback from the collector to the emitter.

2,708,739 Oscillator Frequency Control—T. T. Bucher. Assignee: Radio Corporation of America. A device designed to utilize two diodes connected in a manner designed to substantially reduce the production of even harmonics in the modular circuit, and using diodes as the variable impedance elements for frequency control purposes.

May 24, 1955
2,709,232 Controllable Electrically Unsymmetrically Conductive Device—R. The-

dieck. Assignee: Licentia Patent—Verwaltungs G.m.b.H. (Germany). A device consisting of a semiconductive body composed of an n-type and a p-type portion, two electrodes mounted on said body without blocking layers between the electrodes and the body, and containing two ring shaped electrodes.

May 31, 1955
2,709,780 Constant Voltage Semiconductor Devices—R. J. Kircher. Assignee: Bell Telephone Laboratories. A constant voltage device comprising a body of semiconductive material having a pair of opposed faces, said body having therein a zone of conductivity different from the bulk of said body, an ohmic base connection, collector and emitter connections, and means for maintaining the collector-base voltage substantially constant.
2,709,787 Semiconductor Signal Translating Device—R. J. Kircher. Assignee: Bell Telephone Laboratories. A device consisting of a transistor of n-p-n type construction, an input circuit between the base and the emitter, an output circuit between the base and the collector, and means for establishing a bias current in the base zone in the direction transverse to the carrier path in said body between the emitter and collector zones.

June 7, 1955
2,710,253 Semiconducting Alloy—R. K. Willardson, H. L. Goering, A. E. Middleton. Assignee: The Battelle Development Corporation. A semiconducting material consisting of from 33.5% to 0.93% by weight of gallium, 1.44% to 17.65% by weight of aluminum, and the balance, antimony.

June 14, 1955
2,710,928 Magnetic Control For Scale of Two Devices—G. E. Whitney. Assignee: International Business Machines. The combination of a core of bistable magnetic material, triggering means for starting a change of state of said material, and regenerative means comprising a pair of semiconductor amplifiers for fortifying a change of state started by said triggering means.

July 5, 1955
2,712,619 Dry Disk Rectifier Assemblies—R. H. Zetwo. Assignee: Westinghouse Air Brake Company. A rectifier assembly comprising a cup-shaped member of insulating material having an opening in its bottom wall, a contact member of large heat dissipating area, a lead-in wire secured to the contact member, and a rectifying cell within the cup member.
2,712,620 Blocking Layer Rectifier and Housing Therefor—A. F. Marlet. Assignee: International Standard Electric Corporation. A blocking layer rectifier arrangement comprising a hermetically sealed box having a rectifier therein, said rectifier having a loosely arranged plate within the box, said box having a reduced air pressure within causing the external pressure to force the sidewalls of the box inwards thus pressing the rectifier parts together.
2,712,621 Germanium Pellets and Asymmetrically Conductive Devices Produced Therefrom—H. Q. North. Assignee: General Electric Company. A point-contact rectifying device comprising a solidified droplet of n-type germanium having a diameter no greater than 0.050 inch, and a pair of electrodes in contact therewith.
2,712,625 Motor Speed Regulation System Utilizing Nonlinear Impedance Devices—D. Blitz. Assignee: Raytheon Manufacturing Company. In a motor speed control, the combination of a source of potential, an armature connected in series with an impedance across a potential source, a non-linear and a unidirectional conducting device having the property of conducting appreciable current only when a voltage above a minimum value is applied across it.

July 12, 1955
2,713,177 Heterodyne Converter—R. W. Haegele. Assignee: Sylvania Electric Products Incorporated. A device having a semiconductive translating element, an input signal circuit, a local oscillator circuit, and an output circuit offering matching impedance to the modulation products of the input signals.

2,713,132 Electric Rectifying Devices Employing Semiconductors—K. A. Matthews, R. A. Hyman. Assignee: International Standard Electric Corporation. A crystal rectifier composed of a semiconductive body of a given conductivity type, a low resistance contact electrode, a layer of opposite conductivity type on the surface of said body over part of said layer, another layer of the first conductivity type, and two electrodes spaced apart by a distance $d = k\sqrt{T}$ where T is the current carrier lifetime and k is a constant.

2,713,133 Germanium Diode and Method For The Fabrication Thereof—P. L. Ostapkovich. Assignee: Philco Corporation. A germanium device containing 0.01 to 0.04 per-cent by weight of bismuth and 0.1 to 0.3 per-cent by weight of antimony.

July 19, 1955
2,713,644 Self-Powered Semiconductor Devices—P. Rappaport. Assignee: Radio Corporation of America. A semiconductive device having an electro-chemical power source in contact with a semiconductive body and including said body as one electrode element thereof.

2,713,655 Selenium Rectifier—S. Grubman; Assignee: None. A metallic rectifier comprising two metallic plates each having one side coated with a rectifying compound, said plates being stack mounted with one of said plates being corrugated.

2,713,665 Transistor Modulator Circuits—G. Raisbeck, R. L. Wallace; Assignee: Bell Telephone Laboratories. Apparatus for modulating carrier waves by a signal, which comprises a transistor, means for biasing said transistor to or beyond collector voltage cut-off, and means for applying a modulating signal between base and collector electrodes.

July 26, 1955
2,714,182 Hall Effect Devices—W. H. Hewitt Jr. Assignee: Bell Telephone Laboratories. A Hall effect unit comprising a monocrystalline body of semiconductive material having three mutually perpendicular axes, one crystallographic axis of said body being displaced from a first geometric axis about a second geometric axis by a multiple of 45 degrees.

2,714,183 Semiconductor p-n Junction Units and Method of Making the Same—R. N. Hall, W. E. Burch. Assignee: General Electric Company. A p-n junction device comprisig a semiconductor body of one conductivity type having a bore therein containing an activator element of the opposite conductivity type fused therein to form a rectifying junction with said body.

August 2, 1955
2,714,566 Method of Treating a Germanium Junction Rectifier—L. E. Barton, R. L. Sherwood. Assignee: Radio Corporation of America. A treatment to introduce a layer of opposite conductivity type which consists of electrolytically etching a germanium surface in a solution of not more than $1/200$ per-cent electrolyte solute, free from n-type and p-type impurities, in distilled water.

2,714,694 Rectifier Stack—H. Drubig, J. Eisele, G. Strattner, G. Parow. Assignee: International Standard Electric Corporation. A rectifier stack comprising a plurality of imperforate rectifying plates, a pair of frame members arranged over opposite ends of the plates, said frames having slots therein at the ends thereof, and means of securing said terminal plates in said slots.

2,714,702 Circuits Including Semiconductor Device—W. Shockley. Assignee: Bell Telephone Laboratories. In combination, a p-n junction which for applied reverse voltages greater than a critical reverse voltage, is characterized by a constant voltage region, a source of variable voltage greater than said critical voltage, and means for limiting current flow through the device in said constant voltage regions.

August 16, 1955
2,715,657 Electrical Information System—F. T. Andrews Jr. Assignee: Bell Telephone Laboratories. An electrical system for scanning a plurality of lines each comprising a pair of wires and transmitting information indicating the condition of the lines to a central office remote from said lines.

2,715,718 Voltage-Selection and Comparison System and Method—M. C. Holtje. Assignee: General Radio Company. A system having at least one arm which contains a non-linear device, means for applying a voltage to the bridge input to vary the impedance of the non-linear device, and differential amplifying means interconnecting the input and output of the bridge to provide a pair of opposite-polarity feedback loops.

August 30, 1955
2,716,722 Temperature Stable Solid State Electronic Devices—J. Rothstein. Assignee: None. A device comprising a rigid container, a semiconductive body therein, electrodes in contact with said body, a substance within the container having a high coefficient of expansion, and a pressure transmitting medium whereby a temperature-induced rise in pressure due to the expansion of said substance is transmitted to said semiconductor by said medium.

2,716,729 Transistor Circuits With Constant Output Current—W. Shockley. Assignee: Bell Telephone Laboratories. In combination: a junction transistor, a p-n diode, and means for biasing the diode in a current range where the voltage across said diode is independent of the current flowing therethrough.

September 6, 1955
2,717,341 Asymmetrically Conductive Device—H. Q. North. Assignee: General Electric Company. A device comprising a semiconductive body, two filamentary electrodes making point contact with said body, a low resistance contact electrode, and an insulating layer covering all but the tips of said filamentary electrodes.

New Products

Semiconductor Preforms

High purity precision preforms, including discs, spheres, washers, and pellets used in making alloy junctions in silicon and germanium semiconductor devices are now available in a wide variety of alloys from Accurate Specialties. Specially designed to make readings of plus-or-minus 1/28,000 of an inch possible. Final packaging of preforms with oxidizable elements is accomplished in sealed argon or other suitable atmospheres to assure consistent junction contacts. Available in alloys such as lead-antimony, indium-lead, gold-gallium, aluminum-gallium, and tin-antimony.

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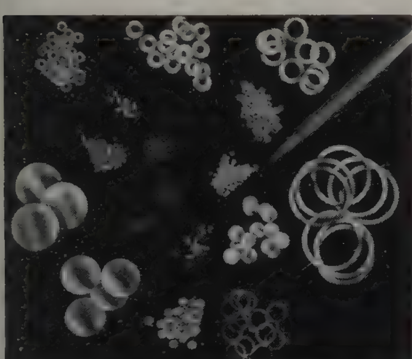

Tiny Tantalum Capacitors

General Instrument Corp. has announced development of production models, new techniques and equipment for mass producing tiny high reliability solid tantalum capacitors, with substantially lower power factors and lower leakage, designed for microminiaturization of missiles gear, communications equipment and other military, industrial and commercial electronic systems. The device is a miniature (three one-thousandths cubic inch) electronic storage cell whose core is a metallic sponge of tantalum. They operate at humidity and temperature extremes; are hermetically sealed in a metal case and are invulnerable to shock and vibration.

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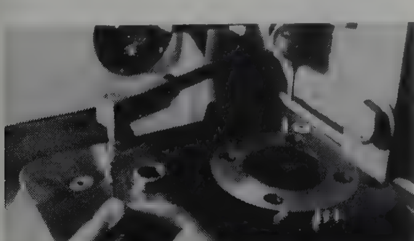

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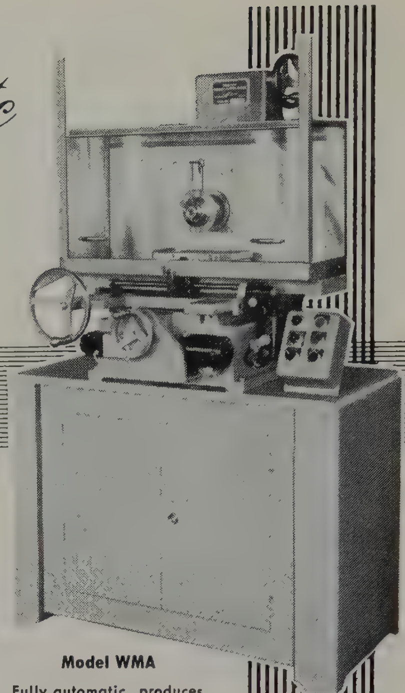
PRECISION WAFERING MACHINES

Models for all jobs requiring very thin slicing of semi-conductor and other difficult-to-cut materials.



Micro-Matic Machines are used by

- ★ Audio Devices, Inc.
- ★ Bell Telephone Laboratories, Inc.
- ★ C.B.S.—Hytron
- ★ Clevite Transistor Products, Inc.
- ★ Federal Telecommunications Laboratories
- ★ General Electric Co.
- ★ International Business Machines Corp.
- ★ Radio Receptor Co., Inc.
- ★ Sperry-Rand Semi-Conductor Facilities
- ★ Texas Instruments, Inc.—Semi-Conductor Components Div.
- ★ Tung-Sol Electric, Inc. and many other leading firms

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Diffused Silicon Rectifiers

Availability of a complete line of heavy-duty diffused silicon stud-mounted rectifiers was announced recently by Texas Instruments. The new TI rectifiers are rated at 50 and 30 amps at a stud temperature of 150°C. They feature recurrent peak inverse voltages of 50 through 600 volts in both the 50-amp and 30-amp series. Operating range for the devices is −65 to +200°C. The stud configuration of the case permits easy mounting of the unit to chassis or heat sink.

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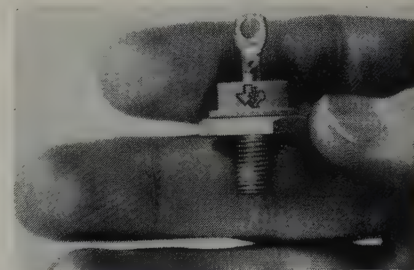

Miniature Quartz Sealcaps

JFD precision Miniature Quartz Sealcaps seal out moisture, seal in reliability and accuracy, regardless of atmosphere. These new variable trimmer piston capacitors combine the unique characteristics of Sealcap construction and miniature quartz capacitor design. Each is filled with dry nitrogen under pressure and then sealed to maintain the compression, prevent corona and voltage breakdown at high altitude. Linear tuning with fine resolution is assured without breaking of seal. Available unpotted or encapsulated in epoxy resin for higher dielectric strength. Request Bulletins 215 and 207A.

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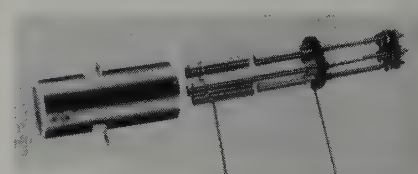

Germanium Power Transistors

Texas Instruments has introduced a complete new line of 10 to 25-amp germanium P-N-P alloy power transistors which is uniquely integrated to permit selection of specialized devices for specific jobs. Featuring high collector currents and voltages, plus a new low R_{cs} of 0.05 ohms maximum at maximum rated collector current, the units provide a dissipation of 80 watts at 25 degrees C. The new line of TI power transistors will be furnished in the standard welded diamond-shaped package.

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Garage Door Control System

A fully transistorized radio controlled garage door operator has been announced by Delco Radio Division of General Motors. The transmitter is car-mounted. Two units are used in the garage to receive the signals from the transmitter in the car. Works in an unused and unrestricted radio frequency band and is designed to reject phantom signals. The transmitter uses two transistors, a low power audio type as an oscillator, and a power transistor as a power amplifier to drive a ferrite rod tuned antenna. The control receiver uses five transistors, two crystal diodes, and a semiconductor rectifier. The single tuned antenna is a ferrite rod design with coils positioned on the rod to resonate with a fixed capacitor at the desired channel. Operating a total of 8760 hours a year, power consumption of the receiver is less than an electric clock.

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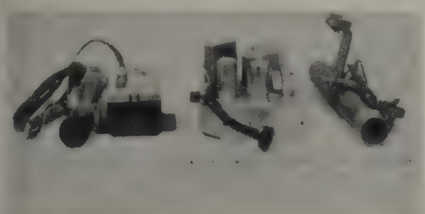

Ultrasonic Liquid Level Switch

A miniature, glass-aluminum sensing element for use with low boiling point fluids has been developed by Acoustica Associates. The new sensor is designed for use with an external miniaturized control unit, which, in combination, form a liquid level switching system. The units in the system are small, lightweight and hermetically sealed, and operate over a wide range of shock, vibration, temperature and altitude. Response time is 25 milliseconds maximum. Functions well in cryogenic and most other fluids at temperatures up to 160°F. The probe itself is only 2 inches long, ¾-inch in diameter and weighs only one ounce. It is designed to operate over the temperature range from −320°F to +160°F and power requirement is only 2 milliwatts (0.002 watts).

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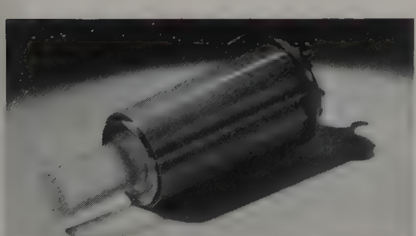

Silicon Rectifiers

Magnetic amplifier and high voltage type silicon rectifiers produced by the double diffusion process have been released by Columbus Electronics. In hermetically sealed, axial lead, top hat design, features of the magnetic amplifier types include extremely low leakage and low forward drop for use in circuits where extremely low reverse currents are of prime consideration. The high voltage types are also hermetically sealed and are available in the axial lead, top hat design for high voltage power supplies, high voltage blocking applications and clipping circuits.

Circle 132 on Reader Service Card

Subminiature Circuit Breaker

A subminiature electrical circuit breaker that is vacuum sealed in a glass envelope about the length of a common pin has been developed by Sylvania Lighting Products, a division of Sylvania Electric Products Inc. Called the "Mite T Breaker," the tiny device is controlled by time and temperature. Only 1⅛ inches long and ⅜ inches in diameter. Provides circuit protection by interrupting current flow when excessive current or external heating occurs. As temperature decreases or the overload is removed, the current path is automatically re-set.

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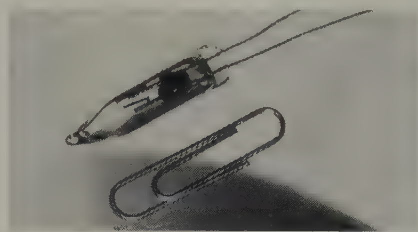

Power Transistor Line

Delco Radio Division announced three new transistors, 2N1172, 2N1159, and 2N-1160, offering a complete line of power transistors available from one manufacturer. In the 10 to 15 ampere range are the 2N174 and 2N1100, improved with germanium wafer material, especially formulated for switching applications. 2N278 is formulated especially for low distortion linear applications. The 2N392 series is for low distortion linear and audio applications. 2N1159 and 2N1160 are formulated especially for switching. The 2N553 series is in the two to three ampere range. The one-half to one ampere is the 2N1172, the new small but husky germanium transistor which can serve as a driver unit or for medium power audio output.

Circle 126 on Reader Service Card

Silicon Switch

A higher power 4-layer diode designated as Type AD has been announced by the Shockley Transistor Corp. This new self-actuated silicon switch is similar in function to a relay or gas tube. It is turned on by a voltage pulse, turned off by dropping the current or reversing the voltage. To match circuit requirements, it is available with switching voltages of 30, 40, 50 and 200 volts and holding currents of 5 to 45 ma. Capable of handling 300 ma steady d.c. or a 20-ampere pulse current.

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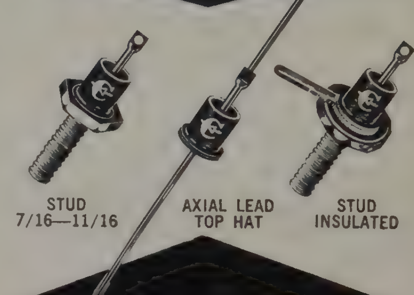
(Continued on Page 53)

COLUMBUS ELECTRONICS CORP.

DOUBLE DIFFUSED SILICON RECTIFIERS



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SINGLE unit VERY HIGH VOLTAGE silicon rectifiers exhibiting these desirable characteristics . . .

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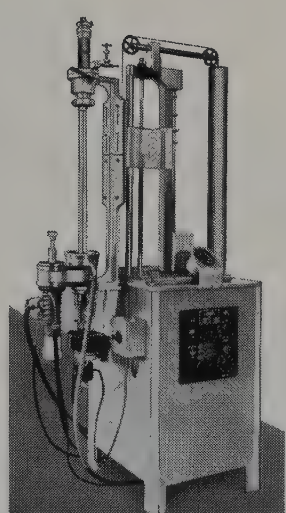
A new floating zone fixture for the production of ultra-high purity metals and semi-conductor materials. Purification or crystal growing is achieved by traversing a narrow molten zone along the length of the process bar while it is being supported vertically in vacuum or inert gas. Designed primarily for production purposes, Model HCP also provides great flexibility for laboratory studies.

Features

- A smooth, positive mechanical drive system with continuously variable up, down and rotational speeds, all independently controlled.
- An arrangement to rapidly center the process bar within a straight walled quartz tube supported between gas-tight, water-cooled end plates. Placement of the quartz tube is rather simple and adapters can be used to accomodate larger diameter tubes for larger process bars.
- Continuous water cooling for the outside of the quartz tube during operation.
- Assembly and dis-assemby of this system including removal of the completed process bar is simple and rapid.



Model HCP

Electronic Tube Generators from 1 kw to 100 kw.
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Industry News

The Following June 1959 IRE and Jointly Sponsored Meetings Are Scheduled:

June 1-3	PGMTT National Symposium, Harvard University, Cambridge, Mass. For Information: Dr. Henry J. Riblet, 92 Broad Street, Wellesley, Mass.
June 4-5	3rd National Conference on Production Techniques, Villa Hotel, San Mateo, Cal. For Information: Emmet G. Cameron, Varian Associates, Palo Alto, Calif.
June 15-20	Symposium on Electromagnetic Theory, University of Toronto, Toronto, Ontario, Canada. For Information: Same.
June 15-20 (Exhibits— June 13-22)	International Conference on Information Processing, UNESCO House, Paris, France & Palais de Exhibition. For Information: A. S. Householder, Oak Ridge Nat'l Lab., Oak Ridge, Tenn.
June 16-18	International Symposium on Circuit & Information Theory, University of California, Los Angeles, Cal. For Information: Dr. G. L. Turin, Hughes Aircraft Co., Culver City, Cal.
June 24-28	International Conference on Medical Electronics, UNESCO House, Paris, France. For Information: Same.
June 29 & 30; July 1	3rd National Convention on Military Electronics, Sheraton Park Hotel, Washington, D. C. For Information: L. R. Everingham, Radiation, Inc., Orlando, Florida.

Factory sales of transistors declined in January over December, the Electronic Industries Association announced recently. Factory sales of transistors in January declined to 5,195,317 units valued at $13,626,886 from the 5,627,700 transistors sold in December valued at $16,595,616. Sales of transistors in January 1958 totaled 2,955,247, EIA reported.

Silicon power transistor prices have been cut by the Westinghouse Electric Corporation up to 30 percent, D. W. Gunther, manager of the company's semiconductor department, has announced. The price cut, effective March 16, will increase the range of applications for 2- and 5-ampere silicon power transistors, first announced by Westinghouse last March. Increased production capabilities, and improved methods for producing ultrapure silicon used in the devices made the price cut possible, Mr. Gunther added. The units involved (Types WX1015 and WX1016) are ideally suited for use in inverters or converters, regulated power supplies, aircraft circuits, amplifiers and in general industrial switching applications.

General Electric Company announced that it has reduced prices on its two (16 amp and 10 amp) lines of silicon controlled rectifiers. The new prices range from six to forty-four percent lower than previous prices. Both lines have voltage ratings from 25 thru 300-volts. W. H. Hall, manager of marketing for the rectifier product section of General Electric's Semiconductor Products Department, who made the announcement, said the lower prices were made possible by increased production and improved yields from the manufacturing process. He cited new mechanized production equipment recently placed in operation as a major contributing factor.

Scientists from Britain and Continental Europe this year will play their greatest role in the 14-year history of the Annual Conference and Exhibit of the Instrument Society of America to be held in Chicago Sept. 21-25. Preliminary arrangements already have been made for participation by at least five authorities from the eastern side of the Atlantic. Dr. C. J. D. M. Verhagen of Delft, The Netherlands, is scheduled to make a keynote address broadly surveying major instrumentation developments overseas during 1959. Highlights will include: At least seven major program events emphasizing the use of computers; The equivalent of one-half days of sessions on photo instrumentation; Management's interest in instrumentation as a route to new levels of process efficiency will be stressed both in conference papers and new equipment displays; Action to help alleviate the shortage of instrument men and other technicians.

Thirteen leading scientists have been appointed to the advisory committee for the International Symposium on High Temperature Technology to be held at Asilomar, California, from October 6 to 9, 1959. The meeting, arranged by Stanford Research Institute, will cover latest developments in techniques and processes for attaining high temperatures, and in high-temperature materials. About 600 scientists and industrialists from the U.S. and abroad are expected to attend, according to Dr. Nevin K. Hiester, manager of SRI's chemical engineering section and chairman of the meeting. Among those attending will be specialists in ceramics, metallurgy, chemistry, aerodynamics, engineering and nuclear physics.

A striking improvement in the floating zone refining technique, substantially increasing the volume of material which can be purified, was described to the American Physical Society by W. G. Pfann, K. E. Benson, and D. W. Hagelbarger of Bell Telephone Laboratories. The floating zone technique has proven highly valuable in producing extreme purity in reactive metals and semiconductors, because the molten material is never in contact with a container. However, it has been limited until now to use with small amounts of material. The primary limitation on the conventional method is the fact that for any given material, there is a maximum height of molten zone which can be supported by the surface tension. The new method gets around this difficulty by using specially shaped cross sections, such as flat plates and tubes. These shapes provide a cross section small in thickness to permit melting through without exceeding the maximum height, and large in width to increase the total cross-sectional area treated.

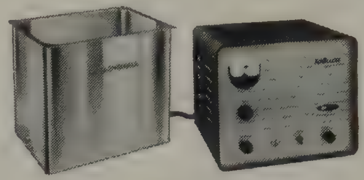
Outstanding progress in a completely new concept in shrinking electronic equipment and products, which has already produced radios as small as sugar lumps and promises a tenfold reduction in size and weight of many vital military devices, was announced by the Department of the Army. Working models showing this concept were

MAMMOTH narda SONBLASTER

America's first mass-produced industrial-size ultrasonic cleaner!

SAVE *7 ways over costly solvent, alkaline or vapor degreasing:*

• Clean faster, speed production! • Cut rejects, eliminate bottlenecks! • Save on chemicals & solvents! • Eliminate expensive installation! • Cut maintenance and downtime! • Save on floor space! • Release labor for other work!



G-1501 generator, NT-1505 tank.

MAMMOTH 5-GALLON TANK $695

Other models from $175. 2-year guarantee on all units.

SPECIFICATIONS

Interior Tank size (in.), 10W x 14L x 9½H. Tank Capacity, 5 gallons.

Submersible Transducers

Model NT-604 — Hermetically sealed heli-arc welded stainless steel case. Radiating face: 27 sq. in. Effective plane of radiation: 40 to 50 sq. in. (approx. 10" x 5"). Effective cavitation of volumes: up to 1200 cu. in. at 24" tank height (5 gal.) and 2400 cu. in. at 48" tank height (10 gal.). Swagelok tube fitting on side or end for internal tank wiring.

Model NT-605 — Same as NT-604 except for bulkhead fitting on back for external wiring. Eliminates electrical conduits in solutions.

Now you can say goodbye to expensive chemicals, solvents, and degreasing equipment . . . reclaim valuable floor space . . . eliminate high installation costs . . . just by installing a Narda Series 1500 SonBlaster. At the same time, you'll get better, faster cleaning, and you'll need fewer people to do the job!

Get the tremendous activity of the new 200-watt Narda SonBlaster, with the largest transducerized tank ever made, at the lowest price in the industry! Choose from transducerized tanks or submersible transducers for use in any arrangement in any shape tank you desire. Up to 4 submersible transducers can be easily operated from the same generator at one time; load selector switch provided — an exclusive Narda feature.

Simply plug the SonBlaster into any 110-115 V AC line, and flip the switch. In seconds, you'll clean 'most any mechanical, optical, electrical, medical or horological part or assembly you can think of. Perfect, too, for brightening, polishing, radioactive decontaminating, pickling, quenching and plating; emulsifying, mixing, sterilizing, impregnating, degassing, and other chemical process applications.

Mail the coupon for free help in determining the model that's best for you.

The SonBlaster catalog line of ultrasonic cleaning equipment ranges from 35 watts to 2.5 KW, and includes transducerized tanks as well as immersible transducers. If ultrasonics can be applied to help improve your process, Narda will recommend the finest, most dependable equipment available — and at the lowest price in the industry!

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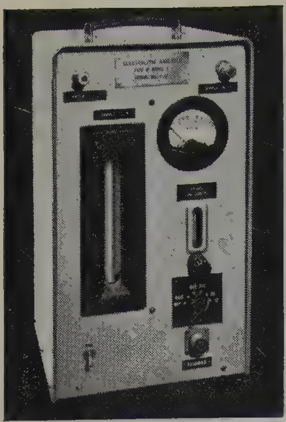

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Useful Applications:

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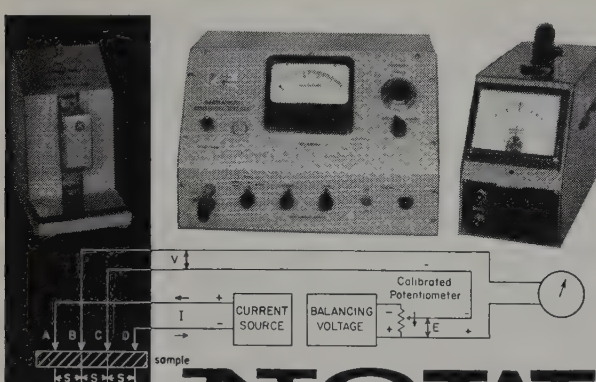

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Extremely simple to operate. A reliable test set for both production quality control and R&D. The "FOUR-POINT-PROBE" can be adapted for silicon measurement as well.

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unveiled recently by the U. S. Army and RCA, the prime contractor. The vast range of jobs done by transistors and other electronic parts is being compressed into tiny micro-modules, circuit building blocks measuring only a third of an inch on each side. A cubic inch will hold 27 of these modules. Some 60 other firms are presently cooperating with RCA by providing materials and components. Further progress of the program is expected eventually to bring in a large part of the electronics industry as equipment makers or element and module suppliers.

A new market research service for manufacturers who sell through electronic parts and sound distributors was announced by J. A. Milling, chairman of EIA's Distributor Relations Committee. The new service is contained in a booklet called Buying Index of Distributors, (BID.) This service enables any electronic parts manufacturer to determine whether he is getting his proper share of the market in each county of the United States. It is a source of market data provided on a current and continuing basis. The BID booklet furnishes a semi-annual barometer, by country, showing: overall sales indices; sales indices by product, and marketing indices by class of business. Companies need not be members of EIA in order to either participate in the service or to obtain copies of the booklet describing BID. The booklet is available to interested manufacturers from William F. E. Long, Manager, EIA Marketing Data Department, 1721 DeSales St., N.W., Washington 6, D.C.

Engineers at International Telephone and Telegraph Laboratories, Nutley, N.J. disclosed that a recently developed version of an electronic device called a parametric amplifier added more than 150,000 miles to the range of missile-tracking equipment at Redstone Arsenal during the space probe flight of Pioneer IV. Attached to the circuitry of a 14-foot dish antenna at the Huntsville, Alabama, rocket base, the amplifier enabled Army Ballistic Missile Agency crews there, to conduct experimental trackings. The Redstone equipment, without aid of the parametric amplifier, was unable to pick up the Pioneer "beep" at 50,000 miles. With the amplifier, the space probe was tracked for 37 hours to a distance of 215,000 miles when the tracking test was discontinued. Part of the device is a tiny diffused silicon diode which is inserted in the receiving circuit to produce a 90% reduction in interference resulting from static electricity and heat forces.

Mallory-Sharon Metals Corporation, Niles, Ohio, has announced that it will expand its vacuum annealing facilities for special metals by adding a new furnace in its Wrought Products Division at the Niles Plant. The new furnace is expected to be in operation by late 1959. Company officials said the move is being made to meet the increasing demands for product quality in metals for the missile and nuclear age. Vacuum annealing reduces the hydrogen content in titanium and zirconium, which improves the mechanical properties of these metals. Equipped to operate at temperatures up to 1950°F. the new furnace will be used to anneal special structural shapes as well as the more conventional mill shapes.

Construction of a $1.5 million Los Angeles plant, doubling its semiconductor production capacity, was announced recently by Hoffman Electronics Corporation. Completion is scheduled for Sept. 1, 1959.

Three years of continually improving safety records culminating in an accident-free year during 1958 won special honors for Raytheon Manufacturing Company's Semiconductor Division when the Massachusetts Safety Council presented its annual awards in Boston recently.

New Products

(*from page 49*)

Environmental Oven

Model RD oven was specifically designed by Gruenberg Electric Company to carry out electrical and resistance tests of electronic components more conveniently under heated conditions. Removable doors equipped with alligator clips mounted on feed through insulators enables components to be clipped on the inside of the door. The loaded door is placed in the oven for heating and tests are made by connection of meters etc. to the studs running from inside to outside. The need for individual leads passing through a penetration in the oven is eliminated. Large components can be accommodated by varying the door design to provide a further support for heavier and bulkier equipment such as coils or transformers.

Circle 133 on Reader Service Card

Diffused Junction Silicon Rectifiers

Motorola offers a wide variety of diffused junction silicon rectifiers in industry standard Top Hat and Stud Mounted welded packages. All units have very low back currents at high temperatures. Exceptionally high surge current handling capacity and excellent stability are other features. Stud mounted types are 1N1115 thru 1N1120 and 1N253 thru 1N256. The Top Hat rectifiers are types 1N536 thru 1N540, 1N1095, 1N1096, and 1N547.

Circle 148 on Reader Service Card

High Temperature Ceramic

Grade HT-2-M, a hi temperature heat shock resistant ceramic suitable to 2200 deg. F. which can be readily machined by the user with no further firing required, is available as rods, discs and custom shapes, it was announced by Duramic Products. Available in diameters from 9/16″ to 2¼″ and in lengths to 1.00″. Has a low thermal expansion rate permitting the material to withstand rapid temperature changes without cracking or spalling. Can be easily machined on conventional machine shop equipment using carbide tipped tools.

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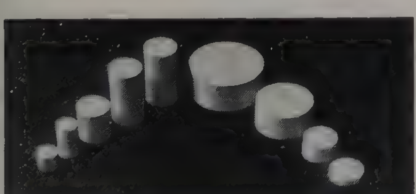

Zone-Refined Silicon

Sylvania announced the availability of an uncompensated silicon in three semiconductor grades. A new zone-refining process produces silicon in which all impurities, except minute quantities of boron, have been removed. Grades are classified according to maximum boron content. Type 43 contains less than 2.8 parts per billion boron, Type 42—5.6 PPB, and Type 41—11.2 PPB. The boron content is calculated from the minimum resistivity measured on a single crystal grown in vacuum by the floating-zone technique. The resistivity measurements are made by a two-point probe at 27 degrees C.

Circle 137 on Reader Service Card

Current-Sensitive Switch

Thermocal, Inc. recently announced their Pyristor Switch, a single shot current-sensitive switch designed for circuitry testing purposes, bypassing squibs, protective devices against surge currents, and applicable in current-operated triggering devices. Pyristors are hermetically sealed and available in normally opened and normally closed, single-pole types.

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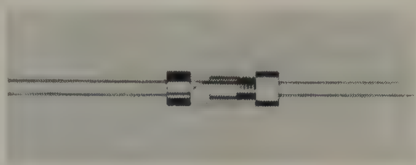

Silicon Controlled Rectifiers

Atomic submarines, guided missiles, jet planes and TV theater lighting panels are expected to be among the first applications for General Electric's new high current silicon controlled rectifiers.

The unit acts like a rectifier by changing alternating current to direct current and like a transistor in controlling the amount of current fed into a circuit. The 50-ampere rectifier measures 2-inches high and 1-inch round. It weighs 3-ounces and occupies less than 2-cubic inches of space. The stud is a one-half inch—20 thread with a 1-1/16-inch hex.

Circle 149 on Reader Service Card

Dual-Beam Oscilloscope

Tektronix Type 555 Dual-Beam Oscilloscope has a separate deflection system for each of the two beams: main vertical amplifier, time-base generator, and vertical and horizontal deflection plates. The two main vertical amplifiers have rise-times of 10 mμsec and are designed to use Tektronix Plug-In Preamplifiers for signal-handling versatility. The two time-base generators provide 24 calibrated sweep rates from 0.1 μsec/cm to 5 sec/cm, with 5 x magnifiers to increase the calibrated rates to 0.02 μsec/cm.

Circle 156 on Reader Service Card

Silicon Power Rectifier

Transitron Electronic Corp. announces a new heavy-duty silicon rectifier. The stud-mounted unit features a high-current rating of 35 amperes @ 150 degrees centigrade case temperature. A standard 11/16″ hex base encapsulation provides ease of mounting and an adequate heat-sink. Peak inverse voltage ratings range from 50 to 400 volts. Operating and storage temperatures range from −65 to 200 degrees centigrade. Request Bulletin PB 54.

Circle 146 on Reader Service Card

Switching Transistor

Hughes Aircraft Company has added a new double diffused switching transistor to its line of semiconductors. HA-9000 silicon transistor designed for medium and low level switching is a P-N-P type. Available in voltage ranges greater than 50 volts and DC current gains greater than 60. Rise times for the transistors are typically in the range of 50 millimicro seconds. Output capacity is 12 micro-microferrites. Other typical specifications are: Operating Temperature Range, −65 C. to +150 C.; Saturation resistance, 30 ohms; Frequency cutoff, 70 megacycles.

Circle 145 on Reader Service Card

Thermoplastic Polymer

J. T. Baker Chemical Company announces the development of a new acrylic-type thermoplastic polymer possessing heat resistance and an exceptional combination of stiffness and toughness. PL-12 has a heat distortion point of 240°F, a flexural modulus of 415,000 psi and a notched izod impact strength of 1.0 ft. lb./inch. Injection molding and extrusion can be carried out by conventional acrylic techniques. The natural resin is straw-colored and has fair transparency.

Circle 142 on Reader Service Card

Voltage Reference Packs

International Rectifier miniaturized voltage reference packs are available to replace standard cells or dry cell batteries in all equipment requiring stable voltage references. Units will operate directly from an unregulated power source. Output voltages of either 8.4 or 16.8 volts dc are available in five types that allow operation from either 28 volt dc or 115 volt dc, 400 and 60 cycle power supplies. Temperature coefficient is ±0.001%/°C from −55° to 100°C. Voltage regulation is ±0.01% (at ±10% line voltage variation). Output ripple from the ac operated types is less than 0.004%. Request Bulletin SSD-401.

Circle 143 on Reader Service Card

Transistor Curve Tracer

Baird-Atomic announces a transistor test instrument for laboratory research or quality production control. MW-1 Curve Tracer is designed to display families of characteristic curves for PNP and NPN transistors in either common base or common emitter configurations. Input and/or output current or voltage may be selected as components of the curves displayed. Displays for either configuration are switch-selected and displays may be reversed or inverted. Plug-in Vacuum Tube Adapter available.

Circle 144 on Reader Service Card

High-Frequency Transistors

GE has announced a line of seven 45-volt silicon high-frequency transistors designed for both amplifier and switching circuits, JEDEC type-designated 2N332 through 2N338. Fixed-bed mounting using a ceramic disk has resulted in unusually high reliability, and low thermal resistance. Accelerated life tests were run at an ambient temperature of 150°C and a dissipation of 75 mw, and also showed an increased electrical stability of the transistors which are made by the grown-diffusion process. In addition, the new design resulted in a lower collector saturation resistance.

Circle 131 on Reader Service Card

CHARACTERISTICS CHART of NEW TRANSISTORS

Announced Between January 1, 1959 and February 28, 1959

MANUFACTURERS (In Order of Code Letters)

ARA— Advanced Research Associates, Inc.
AMP— Amperex Electronic Corp.
BEN— Bendix Aviation Corp.
BOG— Bogue Electric Mfg. Co.
BTHB— British Thomson-Houston Export Co., Ltd.
CBS— CBS-Hytron
CTP— Clevite Transistor Products, Inc.
DEL— Delco Radio Div., General Motors Corp.
EEVB— English Electric Valve Co., Ltd.
ESEB— Edison Swan Electric Co., Ltd.
FCS— Fairchild Semiconductor Corp.
FTHF— French Thomson-Houston Semiconductor Dept.
GECB— General Electric Co., Ltd.
GE— General Electric Co.
GEM— Great Eastern Mfg. Co.
GTC— General Transistor Corp.
HUG— Hughes Aircraft Co.
HIVB— Hivac Ltd.
IND— Industro Transistor Corp.
LCTF— Labortoire Central de Telecommunications
MIN— Minneapolis-Honeywell Regulator Co.
MOT— Motorola, Inc.
MUL— Mullard Ltd.
NTLB— Newmarket Transistors Ltd.
NPC— Nucleonics Products Co.
PSI— Pacific Semiconductors, Inc.
PHI— Philco Corp., Landsdale Tube Co.
RAY— Raytheon Mfg. Co.
RCA— Radio Corp. of America, Semiconductor Div.
SIE— Siemens & Halske Aktiengesellschaft
SONY— Sony Corp.
SPE— Sperry Gyroscope Co.
SPR— Sprague Electric Co.
SYL— Sylvania Electric Products Inc.
STCB— Standard Telephone & Cables, Ltd.
TKAD— Suddeutsche Telefon-Apparate-, Kabel und Drahtwerke
TRA— Transitron Electronic Corp.
TFKG— Telefunken Ltd.
TI— Texas Instruments
TUN— Tung-Sol Electric, Inc.
WEC— Western Electric Co., Inc.
WEST— Westinghouse Electric Corp.

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C				Typical Characteristics	Gain		MFR. See code at start of charts
				P_c (mw)	DERATING °C/W	V_{CB}	V_{CE}	$f_{\alpha b}$ (mc)	PARAMETER and (condition)	VALUE	
2N392	5	PNPA	Ge	45W	1.5	60	30		h_{FE}:I_C-3.0A	100	DEL
2N538	3	PNPA	Ge	32W	2.2	80	60	.20	h_{FE}:I_C-2.0A	30	MIN
2N538A	3	PNPA	Ge	32W	2.2	80	60	.20	h_{FE}:I_C-2.0A	30	MIN
2N539	3	PNPA	Ge	32W	2.2	80	60	.20	h_{FE}:I_C-2.0A	43	MIN
2N539A	3	PNPA	Ge	32W	2.2	80	60	.20	h_{FE}:I_C-2.0A	43	MIN
2N540	3	PNPA	Ge	32W	2.2	80	60	.20	h_{FE}:I_C-2.0A	64	MIN
2N540A	3	PNPA	Ge	32W	2.2	80	60	.20	h_{FE}:I_C-2.0A	64	MIN
2N545	3,5	NPND	Si	5.0W		60	60	4.0	h_{FE}:I_C-.50A	25	TRA
2N546	3,5	NPND	Si	5.0W		30	30	4.0	h_{FE}:I_C-.50A	25	TRA
2N547	3,5	NPND	Si	5.0W		60	60	4.0	h_{FE}:I_C-.50A	35	TRA
2N548	3,5	NPND	Si	5.0W		30	30	4.0	h_{FE}:I_C-.50A	35	TRA
2N549	3,5	NPND	Si	5.0W		60	60	4.0	h_{FE}:I_C-.50A	35	TRA
2N550	3,5	NPND	Si	5.0W		60	60	4.0	h_{FE}:I_C-.50A	35	TRA
2N551	3,5	NPND	Si	5.0W		60	60	4.0	h_{FE}:I_C-.50A	30	TRA
2N552	3,5	NPND	Si	5.0W		30	30	4.0	h_{FE}:I_C-.50A	30	TRA
2N634	5	NPN	Ge	150	400	20		8.0	h_{FE}:I_C-200ma	15	GE
2N635	5	NPN	Ge	150	400	20		12	h_{FE}:I_C-200ma	25	GE
2N636	5	NPN	Ge	150	400	15		17	h_{FE}:I_C-200ma	35	GE
2N665	5	PNPA	Ge		2.0	80	40		h_{FE}:I_C-.50A	60	DEL
2N1056	5	PNP	Ge	240		50		1.0	h_{FE}:	32	GE

NOTATIONS

Under Use

1—Low power a-f equal to or less than 50 mw
2—Medium power a-f > 50 mw and equal to or less than 500 mw
3—Power > 500 mw
4—r-f/i-f
5—Switching & Computer

Under Type

A—Alloyed
D—Diffused or Drift
G—Grown
H—Hook Collector
M—Microalloy
O—Other
P—Previously released with new specs
S—Surface Barrier
UNI—Unijunction Transistor
Y—Symmetrical

Under $f_{\alpha b}$

* Maximum Frequency
# Figure of Merit
△ $f_{\alpha e}$
Ø minimum

PHILCO Transistors operate

51,614,343

SERVICE HOURS*

in High-Speed Computer Circuits

with only 8 Failures!‡

Total Transistor Service Hours To Date	Total Transistors	Total Failures‡	Report
1,068,111	99	0	ELECTRONICS, Oct. 1, 1957, pg. 167
5,460,000	600	1	ELECTRONICS, Oct. 1, 1957, pg. 167
1,250,000	125	0	PHILCO REPORT, Feb. 10, 1959
16,000,000	10,192	2	WJCC REPORT, Feb. 1957
8,640,000	8,000	2	PHILCO REPORT, Feb. 12, 1959
19,196,232	18,601	3	PHILCO REPORT, Nov. 19, 1958

‡Failures due to all causes including human error.

Circle No. 28 on Reader Service Card

Carefully documented reports now reveal that Philco electro-chemical transistors have amassed more than fifty-million hours of operation in six computers under actual field conditions. Here is proof of the outstanding performance and reliability that electronics engineers and designers have come to expect from Transistor Center, U.S.A. Of course, these transistors are still operating in their original high speed computer switching circuits . . . extending service life data on these transistors beyond the limits of any previously published information.

When you think of transistors, think first of Philco. Make Philco your prime source for all transistor information.

Write to Lansdale Tube Company, Division of Philco Corporation, Lansdale, Pa., Dept. SC 559

*Documented service hours in these six computers only. Total transistors hours in similar circuits are many times this amount.

PHILCO CORPORATION

LANSDALE TUBE COMPANY DIVISION

LANSDALE, PENNSYLVANIA

CHARACTERISTICS CHART of NEW TRANSISTORS

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C: P_c (mw)	Max. Ratings @ 25° C: DERATING °C/W	Max. Ratings @ 25° C: V_{CB}	Max. Ratings @ 25° C: V_{CE}	Typical Characteristics: $f_{\alpha\beta}$ (mc)	Typical Characteristics: Gain: PARAMETER and (condition)	Typical Characteristics: Gain: VALUE	MFR. See code at start of charts
2N1057	5	PNP	Ge	240		30		1.3	h_{FE}:	58	GE
2N1067	3,5	PNPD	Si	5.0W	30	60	60	1.5	$h_{FE}:I_C$-200ma	35	RCA
2N1068	3,5	PNPD	Si	10W	15	60	60	1.5	$h_{FE}:I_C$-750ma	38	RCA
2N1069	3,5	NPND	Si	50W	3.0	60	60	1.2	$h_{FE}:I_C$-1.5A	20	RCA
2N1070	3,5	NPND	Si	50W	3.0	60	60	1.2	$h_{FE}:I_C$-1.5A	20	RCA
2N1090	2,5	NPNA	Ge	120		25	18	7.0	$h_{FE}:I_C$-200ma	35	RCA
2N1091	2,5	NPNA	Ge	120		25	15	13	$h_{FE}:I_C$-200ma	55	RCA
2N1092	3	NPND	Si	2.0W	75	60	60	1.5	$h_{FE}:I_C$-200ma	35	RCA
2N1116	3,5	NPND	Si	5.0W		60	60	4.0	$h_{FE}:I_C$-.50A	70	TRA
2N1117	3,5	NPND	Si	5.0W		60	60	4.0	$h_{FE}:I_C$-.20A	70	TRA
2N1159	5	PNPA	Ge		1.2	80	60		$h_{FE}:I_C$-3.0A	50	DEL
2N1160	5	PNPA	Ge		1.2	80	60		$h_{FE}:I_C$-5.0A	35	DEL
2N1161	3	Composite PNP	Si	50K	2.7	40	40	.03	h_{fe}:	10,000	ARA
2N1162	3	PNPA	Ge	50W	1.2	50	35	.26	$h_{FE}:I_C$- 25A	25	MOT
2N1163	3	PNPA	Ge	50W	1.2	50	35	.26	$h_{FE}:I_C$- 25A	25	MOT
2N1164	3	PNPA	Ge	50W	1.2	80	60	.26	$h_{FE}:I_C$- 25A	25	MOT
2N1165	3	PNPA	Ge	50W	1.2	80	60	.26	$h_{FE}:I_C$- 25A	25	MOT
2N1168	5	PNPA	Ge	45	1.5	50	30		$h_{FE}:I_C$-3.0A	60	DEL
2N1172	5	PNPA	Ge		15	40			$h_{FE}:I_C$-.50A	30	DEL
2N1191	2	PNPA	Ge	175	350	40	25	1.5	$h_{fe}:I_e$-1.0ma	40	MOT
2N1192	2	PNPA	Ge	175	350	40	25	2.0	$h_{fe}:I_e$-1.0ma	75	MOT
2N1193	2	PNPA	Ge	175	350	40	25	2.5	$h_{fe}:I_e$-1.0ma	160	MOT
2N1202	3	PNPA	Ge	32W	2.2	80	60	.20	$h_{FE}:I_C$-.50A	86	MIN
2N1203	3	PNPA	Ge	32W	2.2	120	70	.20	$h_{FE}:I_C$-2.0A	37	MIN
2T64R	2	NPNA	Ge	80	625	25		1.0	$h_{FE}:I_C$- 10ma	100	SONY
2T65R	2	NPNA	Ge	80	625	25		1.0	$h_{FE}:I_C$- 10ma	50	SONY
2T66R	2	NPNA	Ge	80	625	25		.80	$h_{FE}:I_C$- 10ma	25	SONY
2T69R	2	NPNA	Ge	100	600	25		1.0	$h_{FE}:I_C$- 10ma	50	SONY
2T73R	1	NPNG	Ge	50	1000	15		20	$h_{fe}:I_e$-1.0ma	49	SONY
2T76R	1	NPNG	Ge	50	1000	15		10	$h_{fe}:I_e$-1.0ma	49	SONY
2T78R	1	NPNG	Ge	50	1000	15		20	$h_{fe}:I_e$-1.0ma	49	SONY
2T204A	1	PNPG	Ge	25	1600	15		60	$h_{fe}:I_e$-1.0ma	49	SONY
2T205A	1	PNPG	Ge	25	1600	15		80	$h_{fe}:I_e$-1.0ma	49	SONY
2T681	2	NPNA	Ge	100	600	30		1.0	$h_{FE}:I_C$- 10ma	50	SONY
2T682	2	NPNA	Ge	100	600	30		1.0	$h_{FE}:I_C$- 10ma	50	SONY
GET571	3,5	PNPA	Ge	25W	2.5	16	16	.25	h_{FE}: 12A	20	GECB
GET572	3,5	PNPA	Ge	25W	2.5	32	32	.25	h_{FE}: 12A	20	GECB
GET573	3,5	PNPA	Ge	25W	2.5	64	40	.25	h_{FE}: 12A	20	GECB
LT5163	3	NPNA	Ge	12W	5.0	60	45	.15	$h_{FE}:I_C$-1.0A	35	CBS
LT5163L	3	NPNA	Ge	12W	5.0	60	45	.15	$h_{FE}:I_C$-1.0A	35	CBS
LT5164	3	NPNA	Ge	12W	5.0	80	60	.15	$h_{FE}:I_C$-1.0A	35	CBS
LT5164L	3	NPNA	Ge	12W	5.0	80	60	.15	$h_{FE}:I_C$-1.0A	35	CBS
LT5165	3	NPNA	Ge	12W	5.0	35	30	.15	$h_{FE}:I_C$-1.0A	35	CBS
LT5165L	3	NPNA	Ge	12W	5.0	30	30	.15	$h_{FE}:I_C$-1.0A	35	CBS
OC19	3	PNPA	Ge		1.0	16	16	.20	$h_{FE}:I_C$-.30A	45	MUL

NOTATIONS

Under Use

1—Low power a-f equal to or less than 50 mw
2—Medium power a-f > 50 mw and equal to or less than 500 mw
3—Power > 500 mw
4—r-f/i-f
5—Switching & Computer

Under Type

A—Alloyed
D—Diffused or Drift
G—Grown
H—Hook Collector
M—Microalloy
O—Other
P—Previously released with new specs
S—Surface Barrier
UNI—Unijunction Transistor
Y—Symmetrical

Under $f_{\alpha b}$

* Maximum Frequency
\# Figure of Merit
△ $f_{\alpha e}$
Ø minimum

From Transistor Center, U.S.A. ...

PHILCO®

announces a new family of LOW COST Medium Power Alloy Junction Transistors

Introducing a completely new family of PNP germanium transistors, especially designed to meet rigid military and industrial specifications . . . at lowest possible prices.

These transistors are available in production quantities, for use in teletypewriters, control amplifiers, ignition systems, mobile radios and desk calculators (2N1124); servo amplifiers, voltage regulators and pulse amplifiers (2N1125, 2N1126, 2N1127); medium power audio and switching applications (2N1128, 2N1129, 2N1130).

Also available in quantities 1-99 from your local Philco Industrial Semiconductor Distributor.

Make Philco your prime source of information for all transistor applications. Write to Lansdale Tube Company, Division of Philco Corporation, Lansdale, Pa., Dept. SC 559

	TYPE	V_{CE} Max. (Volts)	V_{CB} Max. (Volts)	Peak I_C (Amps)	P Max. (Watts)	$f_{\alpha b}$ (MC)	[illegible]	Applications	PRICE
	**2N1124**	40	35	0.5	0.3	0.4 Min	h_{fe} 40 Min	For high voltage general purpose use in amplifier and switching. Small signal beta controlled.	**$ 1.30**
	2N1125	40	40	0.5	0.3	1.0 Min	$\overline{h_{fe}}$ 50-150 @ 0.5 amp	For high voltage, higher frequency industrial amplifier and switching systems. Large signal beta controlled.	**$1.90**
	**2N1126**	40	35	0.5	1.0	0.4 Min	h_{fe} 40 Min	1 watt version of 2N1124 for servo amplifiers and relay actuators. Small signal beta controlled.	**$1.80**
	2N1127	40	40	0.5	1.0	1.0 Min	h_{FE} 50-150 @ 0.5 amp	1 watt version of 2N1125 for servo amplifiers and control systems. DC beta controlled.	**$2.40**
	**2N1128**	25	18	0.5	0.15	1.0	h_{fe} 70-150	For low distortion, high level driver and output application. Small signal beta controlled.	**$ .95**
	2N1129	25	25	0.5	0.15	0.75	h_{FE} 100-200 @ 0.1 amp	For high gain general purpose amplifier and switching. Typical DC beta 165.	**$1.10**
	2N1130	30		0.5	0.15	0.75	h_{FE} 50-165 @ 0.1 amp	For higher voltage, higher level amplifier and switching applications. Typical DC beta 125.	**$ .95**

Available in Production Quantities—Also Available from Local Distributors

Circle No. 29 on Reader Service Card

PHILCO CORPORATION

LANSDALE TUBE COMPANY DIVISION

LANSDALE, PENNSYLVANIA

CHARACTERISTICS CHART of NEW TRANSISTORS

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C: P_c (mw)	DERATING °C/W	V_{CB}	V_{CE}	Typical Characteristics: $f_{\alpha\beta}$ (mc)	Gain: PARAMETER and (condition)	VALUE	MFR. See code at start of charts
OC22	3	PNPA	Ge		3.0	24	24	2.5	h_{FE}:I_C-1.0A	150	MUL
OC23	3	PNPA	Ge		3.0	24	24	2.5	h_{FE}:I_C-1.0A	150	MUL
OC24	3	PNPA	Ge		3.0	24	24	2.5	h_{FE}:I_C-1.0A	150	MUL
OC30	3	PNPA	Ge		7.5	16	16	.30	h_{FE}:I_C-.80A	28	MUL
OC41	2,5	PNPA	Ge	70	700	16		4.0#	h_{fe}:I_c- 50ma	35	MUL
OC42	2,5	PNPA	Ge	70	700	16		7.0#	h_{fe}:I_e- 50ma	70	MUL
OC60	1	PNPA	Ge	10	1500	7.0			h_{fe}:I_e-.50ma	60	MUL
OC139	2,5	NPNAY	Ge	100	500	20		3.5	h_{fe}:I_e-200ma	14	MUL
OC140	2,5	NPNAY	Ge	100	500	20		4.5	h_{fe}:I_e-200ma	35	MUL
OC170	2	PNPD	Ge	100	500	20		70	h_{fe}:I_c-1.0ma	80	MUL
TK28B	2,5	PNPA	Ge	200	250	26	8.0	9.0	h_{FE}:I_C- 60ma	55	STCB
TK70A	2,4	NPNA	Si	325	370	30	20	6.0	h_{FE}:I_C-100ma	40	STCB
TK71A	2,4	NPNA	Si	325	370	30	25	2.5	h_{FE}:I_C-100ma	15	STCB

The $f\alpha_b$ values for the following transistors were incorrectly listed in the March 1959 issue. Shown below are the correct values.

2N1146	3	PNPA	Ge	70W	1.0	40	40	.004	h_{FE}:I_C- 5A	100	CTP
2N1146A	3	PNPA	Ge	70W	1.0	60	60	.004	h_{FE}:I_C- 5A	100	CTP
2N1146B	3	PNPA	Ge	70W	1.0	80	80	.004	h_{FE}:I_C- 5A	100	CTP
2N1146C	3	PNPA	Ge	70W	1.0	100	100	.004	h_{FE}:I_C- 5A	100	CTP
2N1147	3	PNPA	Ge	70W	1.0	40	40	.004	h_{FE}:I_C- 5A	100	CTP
2N1147A	3	PNPA	Ge	70W	1.0	60	60	.004	h_{FE}:I_C- 5A	100	CTP
2N1147B	3	PNPA	Ge	70W	1.0	80	80	.004	h_{FE}:I_C- 5A	100	CTP
2N1147C	3	PNPA	Ge	70W	1.0	100	100	.004	h_{FE}:I_C- 5A	100	CTP

NOTATIONS

Under Use

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5—Switching & Computer

Under Type

A—Alloyed
D—Diffused or Drift
G—Grown
H—Hook Collector
M—Microalloy
O—Other
P—Previously released with new specs
S—Surface Barrier
UNI—Unijunction Transistor
Y—Symmetrical

Under $f\alpha b$

* Maximum Frequency
# Figure of Merit
△ $f\alpha e$
Ø minimum

The following manufacturers have announced that they have begun supplying the indicated previously registered transistors.

CBS-Hytron: 2N326
Industro: 2N315A, 2N316A, 2N317A, 2N519A, 2N520A, 2N521A, 2N522A, 2N523A
RCA: 2N456, 2N457
Sprague: 2N1122, 2N1122A
Tung-Sol: 2N173, 2N174, 2N174A, 2N277, 2N278, 2N441, 2N442, 2N443

A Complete Line of

COMPUTER TRANSISTORS

Only Philco offers a complete line of specially designed computer transistors. Here are the best transistors for all phases of logic circuitry, read-in and read-out equipment, core-drivers, storage and switching devices.

Philco transistors are being used by all leading computer manufacturers, especially where millimicrosecond speeds are needed. A leading University has proven Philco transistor reliability in actual computer circuits over tens of millions of transistor service hours.

All Philco transistors are hermetically sealed to insure maximum service life. Available in production quantities from the factory. Also available "off the shelf" in quantities 1 to 99 from your local Philco transistor distributor. When you think of TRANSISTORS . . . think of PHILCO FIRST.

Circle No. 30 on Reader Service Card

MEDIUM FREQUENCY, MEDIUM POWER ALLOY JUNCTION TRANSISTORS (250 mw) (in TO-9 package)

2N597......for use in 200-300 kc computers, $f\alpha_b$ over 3 mc
2N598......for use in 300-400 kc computers, $f\alpha_b$ over 5 mc
2N599......for use in switching circuits faster than 400 kc, $f\alpha_b$ over 12 mc

MICRO-MINIATURE TRANSISTOR

2N536......high gain switching transistor, 20v maximum V_{CE}, DC beta typically 150

HIGH FREQUENCY, HIGH GAIN (MICRO ALLOY) TRANSISTOR (MAT)

2N393......combines high frequency response with high gain for general purpose, high frequency applications and switching circuits, typical f_{max} 60 mc

HIGH FREQUENCY SILICON TRANSISTOR (SAT)

2N496......high speed silicon switch for speeds up to 5 mc characterized by extremely low saturation resistance.

HIGH FREQUENCY SURFACE BARRIER TRANSISTOR (SBT)

2N240......switching transistor, typical $f=60$ mc

MICRO ALLOY DIFFUSED-BASE TRANSISTOR (MADT)

2N501......extremely high speed switch; typical rise time 12 $m\mu$ sec, fall time 4 $m\mu$ sec

BILATERAL ALLOY JUNCTION TRANSISTOR

2N462......high gain ($h_{FE} = 45$ in both directions), high voltage (40v) unit for applications where current reversal is desired

POWER TRANSISTORS

2N353......40 volt, 30 watt power transistor
2N386......60 volt, 37.5 watt power transistor
2N387......80 volt, 37.5 watt power transistor
2N589......100 volt, 37.5 watt power transistor

PHILCO'S NEWEST FAMILY OF MEDIUM- AND HIGH-POWER SWITCHING TRANSISTORS

2N670......300 mw, 2 amp pulse amplifier, in TO-9 type package
2N671......40 volt, 1 watt pulse amplifier in case with mounting stud and JETEC E3-51 base
2N672......40 volt, 0.75 microsecond high frequency switching transistor
2N673......40 volt, 1 watt, stud mounted switching transistor
2N600......stud mounted ¾ watt high speed power switch ($f\alpha_c$ and 5 MC)
2N601......stud mounted ¾ watt high speed power switch ($f\alpha_c$ and 12 MC)

Make Philco Your Prime Source For All Transistor Information And Prices. Write Dept. SC-559

PHILCO CORPORATION

LANSDALE TUBE COMPANY DIVISION

LANSDALE, PENNSYLVANIA

TRANSISTOR CENTER U.S.A.

CHARACTERISTICS CHARTS OF SILICON ZENER OR AVALANCHE DIODES

announced between Dec. 1, 1958 and Jan. 31, 1959 only.

Switching diodes, voltage variable capacitor diodes, and miscellaneous diodes announced during this period will be included in June, 1959 issue.

TYPE NO.	Zener or Avalanche Voltage Range			Dynamic Impedance		MAX. DISS.	TEMP. CO-EF-FICIENT	MFR. (See code at start of chart)
	MIN. E_{b1} (volts)	MAX. E_{b2} (volts)	@ I_z (ma)	Z (ohms)	@ I_z (ma)	(mw)	%/°C	
1N2163	9.0	9.8	10	15	10		.005	USS
1N2163A	9.2	9.6	10	15	10		.005	USS
1N2164	9.0	9.8	10	15	10		.005	USS
1N2164A	9.2	9.6	10	15	10		.005	USS
1N2165	9.0	9.8	10	15	10		.005	USS
1N2165A	9.2	9.6	10	15	10		.005	USS
1N2166	9.0	9.8	10	15	10		.001	USS
1N2166A	9.2	9.6	10	15	10		.001	USS
1N2167	9.0	9.8	10	15	10		.001	USS
1N2167A	9.2	9.6	10	15	10		.001	USS
1N2168	9.0	9.8	10	15	10		.001	USS
1N2168A	9.2	9.6	10	15	10		.001	USS
1N2169	9.0	9.8	10	15	10		.0005	USS
1N2169A	9.2	9.6	10	15	10		.0005	USS
1N2170	9.0	9.8	10	15	10		.0005	USS
1N2170A	9.2	9.8	10	15	10		.0005	USS
1N2171	9.0	9.8	10	15	10		.0005	USS
1N2171A	9.2	9.6	10	15	10		.0005	USS
KS4	6.4	7.6	1.0	5.0	5.0	150	.35	FERB
KS5	7.4	8.6	1.0	15	5.0	150	.40	FERB
S180*	6.0	7.5	1.0	8.0	10	250		SSD
ZB3.9	3.6	4.3	80	1.25	35	750	.04	ITT
ZB4.7	4.3	5.1	150	1.25	30	750	0	ITT
ZB5.6	5.1	6.2	130	2.0	26	750	.03	ITT
ZB6.8	6.2	7.5	110	2.5	22	750	.05	ITT
ZB8.2	7.5	9.1	90	4.0	18	750	.06	ITT
ZB10	9.1	11	75	6.0	15	750	.07	ITT
ZB12	11	13	60	10	12	750	.075	ITT
ZB15	13	16	50	20	10	750	.08	ITT
ZB18	16	20	40	40	8.0	750	.085	ITT
ZB22	20	24	33	60	6.0	750	.09	ITT
ZB27	24	30	26	75	5.0	750	.095	ITT
ZG3.9	3.6	4.3	850	.50	150	3500	.04	ITT
ZG4.7	4.3	5.1	700	.50	125	3500	0	ITT
ZG5.6	5.1	6.2	625	.75	110	3500	.03	ITT
ZG6.8	6.2	7.5	525	1.0	100	3500	.05	ITT
ZG8.2	7.5	9.1	425	1.5	80	3500	.06	ITT
ZG10	9.1	11	350	2.5	70	3500	.07	ITT
ZG12	11	13	275	4.0	50	3500	.075	ITT
ZG15	13	16	225	7.5	40	3500	.08	ITT
ZG18	16	20	200	15	35	3500	.085	ITT
ZG22	20	24	160	22.5	30	3500	.09	ITT
ZG27	24	30	125	30	25	3500	.095	ITT
ZK3.9	3.6	4.3	2500	.25	500	10W	.04	ITT
ZK4.7	4.3	5.1	2000	.25	400	10W	0	ITT
ZK5.6	5.1	6.2	1750	.40	350	10W	.03	ITT
ZK6.8	6.2	7.5	1500	.50	300	10W	.05	ITT
ZK8.2	7.5	9.1	1200	.75	250	10W	.06	ITT
ZK10	9.1	11	1000	1.25	200	10W	.07	ITT
ZK12	11	13	850	2.0	170	10W	.075	ITT
ZK15	13	16	650	4.0	140	10W	.08	ITT
ZK18	16	20	550	7.5	110	10W	.085	ITT
ZK22	20	24	450	12	90	10W	.09	ITT
ZK27	24	30	350	15	70	10W	.095	ITT
ZT3.9	3.6	4.3	250	1.0	50	1000	.04	ITT
ZT4.7	4.3	5.1	200	1.0	40	1000	0	ITT
ZT5.6	5.1	6.2	175	1.5	35	1000	.03	ITT
ZT6.8	6.2	7.5	150	2.0	30	1000	.05	ITT
ZT8.2	7.5	9.1	120	3.0	25	1000	.06	ITT
ZT10	9.1	11	100	4.5	20	1000	.07	ITT
ZT12	11	13	80	7.5	15	1000	.075	ITT
ZT15	13	16	65	15	13	1000	.08	ITT
ZT18	16	20	55	30	10	1000	.085	ITT
ZT22	20	24	45	45	9.0	1000	.09	ITT
ZT27	24	30	35	60	7.0	1000	.095	ITT

PERSONNEL NOTES

The board of directors of Silicon Transistor Corp., elected Harold Sandler chairman-of-the-board and appointed the following permanent officers: Robert L. Ashley, president; Mr. Sandler, treasurer; Donald Des Jardin, vice-president and secretary; and Randolph Bronson, vice-president.

John G. Goodell, engineering consultant, has been appointed manager of the Production Development Group of the new CBS Laboratories, Stamford, Connecticut, a division of the Columbia Broadcasting System, Inc., according to an announcement today by Dr. Peter C. Goldmark, president of the Laboratories. In his new capacity, Mr. Goodell is in charge of development and production engineering including electro-mechanical design, and will be responsible for the design of commercially producible prototypes of various electronic and mechanical devices.

Joseph Statsinger has joined Servo Corporation of America, New Hyde Park, L.I., New York, as Director of Engineering, it is announced by Henry Blackstone, President of the company. Prior to this, Mr. Statsinger was with the Arma Division of American Bosch Arma Corporation for 14 years. There, most recently, he served as Assistant Chief Engineer in charge of missile guidance. In this capacity he headed an organization of 450 engineers performing research, development, design and testing of guidance systems for the Titan and Atlas intercontinental ballistic missiles.

John G. N. Braithwaite has joined Baird-Atomic, Inc., as senior infrared scientist, according to an anouncement made by Dr. Davis R. Dewey, II, president of the scientific instrument firm. Mr. Braithwaite was formerly associated with the electronics division of the Canadian Westinghouse Company. Before coming to Canada in 1957 he was with the British Tele-communications Research Establishment now called Royal Radar Establishment. He held the position of senior scientific officer with this group in 1951 and was made principal scientific officer in 1956.

A new division, to be known as the Elkon Division, has been announced by G. Barron Mallory, Administrative Vice President of P. R. Mallory & Co. Inc. With headquarters at Du Quoin, Illinois, it will consist of an Electromagnetic Department and a Semiconductor Department. Kenneth M. Schafer is General Manager. The Electromagnetic Department is the successor to the former Vibrator Division. A. B. Tollefsen, Jr. is Chief Engineer. Robert R. Forbes is Manager of the Semiconductor Department in Indianapolis and James M. Hall is Chief Engineer.

The appointment of Hayward K. Mann as Marketing Manager was announced by Joseph S. O'Flaherty, President of Continental Device Corporation. Mr. Mann has been intimately associated with the semiconductor industry for the past six years through his previous position and through his active participation in trade association work. He came to Continental from the semiconductor Division of Hughes Aircraft Company, Los Angeles, where he had served as Manager of Sales since the inception of the division.

Election of Robert S. Caruthers as vice president and technical director of ITT Laboratories, Nutley, New Jersey, research division of International Telephone and Telegraph Corporation, is announced by Henri Busignies, president of the Labs. Mr. Caruthers brings a 23-year background in electronics and communication systems development to his new post as director of general development projects. A former deputy director of research and engineering for the parent corporation, he occupied key engineering and administrative positions with Bell Telephone Laboratories and the Lenkert Electronic Company in San Carlos, Calif.

Andre G. Clavier, who retired recently as vice president and technical director of ITT Laboratories, Nutley, N.J., has been appointed scientific advisor to the Laboratories president, Henri Busignies. Mr. Clavier, who formerly was in charge of company-sponsored projects at the International Telephone and Telegraph research division, has held the post of vice president since 1956 and is celebrating his 30th anniversary with the ITT System.

The appointment of David B. Tolins to the newly-created position of advertising and sales promotion manager of the Semiconductor Division of Sylvania has been announced by Ernest H. Ulm, division general sales manager. Mr. Tolins has been advertising supervisor for Sylvania Electric Tubes, a division of the company, since 1956. He is a former editor of "Sylvania News," published monthly by the company for servicemen, engineers, and electronic parts distributors.

Dr. David A. Conrad, formerly of Bell Telephone Laboratories, has joined Hughes Aircraft Company as head of the analysis group of the engineering laboratory's servo-mechanics section, it was announced by John Black, plant manager of Hughes' Tucson operations. Others simultaneously announced as having joined Hughes' Tucson plant, are: Blanchard Cain, former manager of new programs at American Machine and Foundry, who became head of the mechanical section of the engineering lab. John K. Matsushino, former research engineer of Radioplane Company, Van Nuys, Calif., who became a member of the Hughes technical staff. Edward Sax, formerly of Aeronautical Radio, Inc., Washington, D. C., who became a member of the technical staff.

Fred Maytag II, president of the Maytag Co., has been elected a director of Minneapolis-Honeywell Regulator Co., Paul B. Wishart, Honeywell president, has announced. His election, announced by Paul B. Wishart, Honeywell president, increases the membership of the M-H board of directors to 12.

George Sioles, acoustics engineer, has been named group leader for transducer research in the Acoustics and Magnetics Department of the new CBS Laboratories, Stamford, Connecticut, a division of the Columbia Broadcasting System, Inc., according to an announcement by Dr. Peter C. Goldmark, president of the Laboratories.

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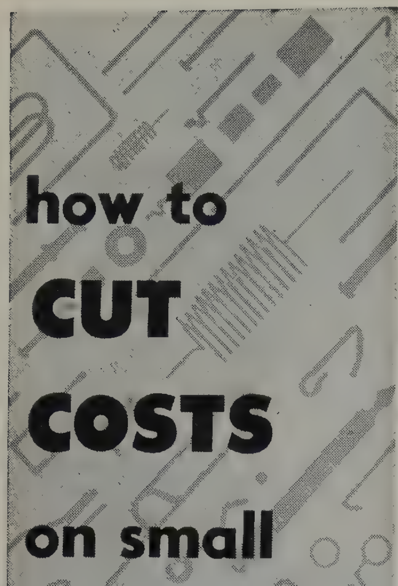

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New Literature

Those concerned with making pressure and vacuum-tight seals with hard glasses will find useful the information contained in the booklet on Kovar Alloy issued by the Carborundum Company. Essential feature of this iron-nickel-cobalt alloy is its thermal expansivity that matches almost perfectly curves for several hard glasses. How this property is employed to best advantage, how to handle the alloy and how to make a Kovar seal with hard glass and ceramics are described in considerable detail. Properties, such as tensile, electrical, magnetic, thermal etc., have tabulated values provided. Also included is a range of stock sizes of finished forms.

Circle 60 on Reader Service Card

Bulletin A-68, a four page illustrated technical bulletin describing high purity semiconductor preforms used in making alloy junctions in germanium and silicon devices, and including information on analyses of alloys, specifications and tolerances of discs, spheres, and washer preforms, along with previously unpublished phase diagrams of semiconductor alloys, is now available from Accurate Specialties, Inc. Bulletin shows typical analyses of semiconductor elements such as lead, antimony, indium, gold, gallium, cadminum, indicating the importance of minimal impurities. Phase diagrams of various semiconductor alloy systems are also included.

Circle 61 on Reader Service Card

The availability of a data sheet on rare earth oxides was announced by Research Chemicals. The rare earths include scandium, yttrium, lanthanum, cerium, praseodymium, neodymium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium and lutetium. Research Chemicals is a division of Nuclear Corporation of America.

Circle 62 on Reader Service Card

Bulletin 400 FS, by Magnetic Circuit Elements, Inc., includes features, drawings, and specifications of a line of frequency sensors for use in automatic instrumentation of frequency for aircraft, missiles, ground control installations, telemetering equipment, and industrial control equipment. The sensors embody magnetic and static elements throughout, and may be used with logic circuits. Accuracy and reliability are high.

Circle 68 on Reader Service Card

An 8-page brochure on wire, rod and shapes, now available in titanium, zirconium, tantalum, columbium and other special metals has been published by Johnston & Funk Metallurgical Corporation. The publication discusses the firm's electrode vacuum melting techniques, and illustrates the facilities available for either manufacturing or experimental research at its plants. In addition to melting, methods of billet conditioning, rolling, wire drawing, cleaning and pickling, wire straightening, strip and foil rolling and laboratory techniques are reviewed.

Circle 69 on Reader Service Card

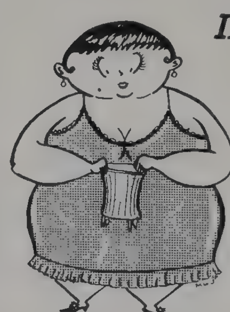
Du Pont has prepared a booklet which helps remove one of the last remaining mysteries confronting the electrical engineer who designs wire and cable insulated with polyethylene. This report, based on 200,000 sample exposure hours, provides the industry with guideposts to designing polyethylene insulation which is free from the effects of corona.

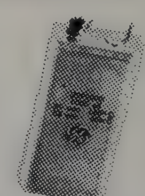
Circle 80 on Reader Service Card

A pamphlet entitled "Notes on Transistor Switching Circuitry," (Navcor Series 100), has been recently published by the Navigation Computer Corp. It deals with pulse generation, programming, flip-flop circuits, counters and other basic switching functions.

Circle 81 on Reader Service Card

Packs A Lot Of Capacity Into A Little Space





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CAPACITORS

The new designs provide up to 40% reduction in weight, and 30% reduction in required space, when compared to other foil tantalum units. They also cost less per volt-microfarad.

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Circle No. 23 on Reader Service Card

Latest edition (Vol. VI) of March 1959 Transistor Characteristics Tabulation now available, containing over 1100 different Transistors. With the engineer's needs in mind, this Tabulation serves as a single source of reference—the Transistors listed first in major characteristics sequence, then in type number sequence showing all manufacturers of each type and cross-referencing the line numbers in the characteristics sections. Subscriptions starting with the March edition of this quarterly Tabulation can be ordered from Derivation And Tabulation Associates, 67 Lawrence Ave., West Orange, N. J.

Circle 79 on Reader Service Card

A technical report describing a proposed standard test set for measuring and evaluating the current noise quality of fixed resistors has been issued by the National Bureau of Standards of the Dept. of Commerce.

Circle 82 on Reader Service Card

Publication of a complete bound reference catalog on basic switches and actuators was announced by Electrosnap Corporation. Catalog ES-59 contains a comprehensive definition of terminology used in the switch industry, as well as photos, specifications, dimensional drawings, and modification information. This 52-page catalog has a pocket where price lists, quotations, and other data may be kept. Supplementary technical literature will be issued periodically to holders of this complete catalog.

Circle 73 on Reader Service Card

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CURRENT GOVERNOR
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for *Constant Current*

- Precision Current Source
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Circle No. 37 on Reader Service Card

Bulletin #117, a 2-page technical data sheet describing Duramic Grade M12OF-T ceramic, a new wear-resistant hi-temperature tooling material for use in alloying of semiconductor materials, including specifications, photos, and fabrication information, is now available from Duramic Products, Inc. Lists detailed fabrication data.

Circle 64 on Reader Service Card

An 8-page catalog entitled "Selenium Photovoltaic Cells," published by International Rectifier Corporation, describes a complete line of self-generating photocells. Over 25 standard selenium cell types are described in the booklet, including cell structure and operation, performance characteristics, output current curves and typical applications in electrical and industrial engineering, chemistry, photography, photometry and medicine. Request Bulletin PC-649A.

Circle 65 on Reader Service Card

The new Stokes SC series of small compound high vacuum pumps, in 2 and 3 cfm. capacities, which are suitable for a wide range of laboratory and production applications where rapid pumping and an ultimate blankoff pressure of 0.1 micron are desired, is described in a bulletin published by the Vacuum Equipment Division of F. J. Stokes Corporation. Specifications and pumping speed curves for the two initial models in the SC series are given, and the pumps' features are outlined.

Circle 66 on Reader Service Card

A technical publication on what to expect from Tantalum Capacitors of the wet electrolytic type has been released by Fansteel Metallurgical Corporation. The 16-page booklet discusses their capabilities and limitations under various electrical and electronic service conditions and shows representative applications. Also includes tables, charts and curves accompanied by a complete textual description on temperature, frequency, surge voltage, shock and vibration conditions, results of life tests both in use and on the shelf.

Circle 72 on Reader Service Card

"Vitramon" Capacitors in five different designs and values from 0.5 mmf to 6800 mmf are described in new 8-page Catalog 59-1. Catalog is profusely illustrated and supplies a wealth of information on the manufacture, electrical characteristics, and design applications of these monolithic, porcelain and silver capacitors.

Circle 78 on Reader Service Card

Precisely-controlled, quick-acting ovens for laboratory sterilizing and special industrial processing applications are described in new literature issued by Despatch Oven Company. The electrically-heated ovens, models 288, 289 and 287, are designed for 400° F. maximum temperature operation. Contains illustrations and detailed specifications for the three oven series.

Circle 76 on Reader Service Card

8-page Data Sheet K-5, contains 29 outline drawings of mica wafer shapes available without tooling costs, and describes how transistor reliability is increased when low cost plentiful mica wafers are used as isolators in heat sink applications. Data Sheet K-5 is available from Magnetic Shield Division Perfection Mica Company.

Circle 74 on Reader Service Card

New

DURAMIC M120F-T CERAMIC SEMICONDUCTOR ALLOYING JIGS

Check these advantages:

- Duramic M120F-T is 4X harder and denser than carbon offering longer tool-life and lower rejects.
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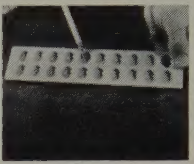

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Super-Sub-Miniature transformers
For transistor circuitry
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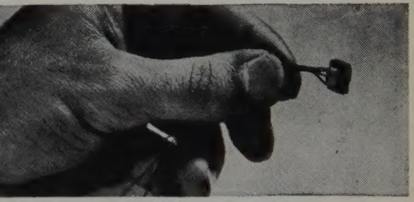

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Type	*H*	*W*	*D*
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F-2010	.263	.410	.325
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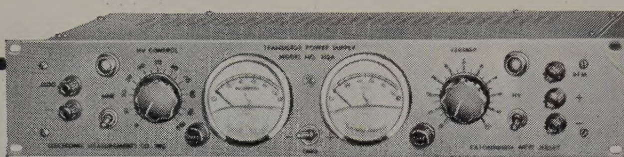
a case history



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0-100 V dc, 0-100 ma,
$129.00 unmetered)

A MANUFACTURER required three different regulated voltages. The voltages, which were to be used alternately, could be furnished by three separate power supplies or by a single power supply and a voltage divider. But, three power supplies were expensive. On the other hand, a voltage divider meant a loss of power and regulation plus the expense of high-wattage components.

THE SOLUTION: Three 1-watt resistors and a *Regatron Programmable Power Supply. An exclusive programming feature permits changing output voltage by shunting two terminals with a resistor. For each 1000 ohms, the Regatron delivers one volt . . . at rated current and regulation.

IN THE PROBLEM quoted here, the required voltages were 14.5, 28, and 45 V dc. The three resistors were 14.5K, 28K, and 45K. Regatron Programmable Power Supplies are available in many ranges up to 600 V dc and 3 amperes. Bulletin 765A tells more about how Programmable Regatrons solve d-c problems. Write for your copy.

POWER FACT No. 6 Ripple and Noise:

Ripple and noise, in some degree, are inherent in all power supplies. The relative importance of given types and magnitudes is closely linked to the application. Surprisingly, external factors may contribute.

For definitions and a useful discussion of these matters, send for Technical Bulletin No. 2006. It is free of charge.

*Registered U.S. Patent Office. U.S. Patents Issued and Pending.

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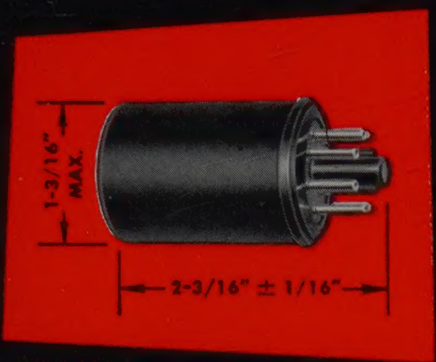
Index to Advertisers

New from Tarzian



Silicon Rectifier Type 5U4 Tube Replacement

The S-5251 rectifier is designed to replace vacuum tube rectifiers in applications where ruggedness and dependability are important. No filament power is required and operation is instantaneous. High efficiency allows saving on transformer cost.

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- *1600 Peak Inverse Volts*
- *600 Milliamperes DC*
- *Direct Replacement*
- *High Efficiency*
- *Horizontal or Vertical Mounting*
- *Good Regulation*
- *Rugged Construction*
- *Immediate B+ Voltage*

MAXIMUM RATINGS FOR S-5251 FULL WAVE SILICON RECTIFIER

PEAK INVERSE VOLTAGE......1600 V MAX. PER SECTION
PEAK RECTIFIER CURRENT....6000 MA MAX. PER SECTION
D.C. OUTPUT CURRENT..................600 MA MAX.
AMBIENT TEMPERATURE...................100°C MAX.
REPLACES...................................TYPE 5U4

Write for Design Note #36

New from Tarzian

Silicon Rectifier Type 6X4 Tube Replacement

A hermetically sealed rectifier designed to replace Type 6X4 rectifier tubes. The 500 milliampere rating allows replacing 5 tubes in parallel in applications that require higher values of B+ current than one tube can deliver. No filament power demand and high efficiency make this an ideal type in many applications.

- *Small Size*
- *Directly Interchangeable*
- *High Efficiency*
- *No Filament Power*
- *500 ma dc, 1600 piv*
- *Rugged Construction*
- *Hermetically Sealed*

MAXIMUM RATINGS FOR S-5207 FULL WAVE SILICON RECTIFIER

PEAK INVERSE VOLTAGE......1600 V MAX. PER SECTION
PEAK RECTIFIER CURRENT....5000 MA MAX. PER SECTION
D.C. OUTPUT CURRENT..................500 MA MAX.
AMBIENT TEMPERATURE...................100°C MAX.
REPLACES...................................TYPE 6X4

Write for Design Note #37

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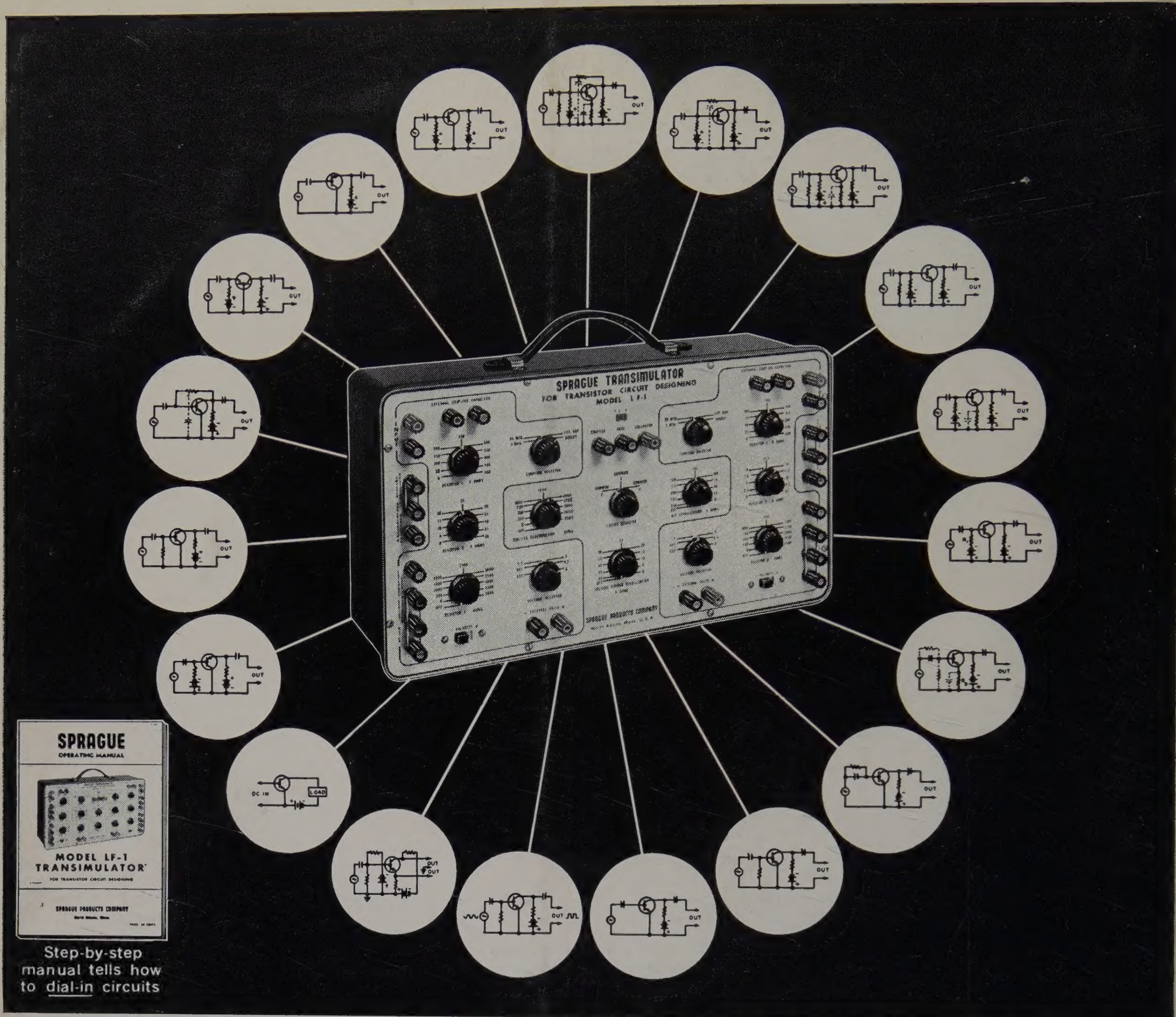

Step-by-step manual tells how to dial-in circuits

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